HARMSWORTH SELF-EDUCATOR

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1907

Vol. VII. Pages 5233—6096

A KEY TO THE HARMSWORTH SELF-EDUCATOR

At the heading of each article in the SELF-EDUCATOR is the number of the group to which the article belongs, and a reference to this key indicates precisely the place of the article in the scheme of the book. This key, therefore, enables the student at any time to understand what has preceded and what is to follow any part of the work to which he may happen to turn.

GROUP 1.

Agriculture. Beekeeping. Gardening.

FARMING. In all its Branches. Dairying. Poultry.
BEEKEEPING. A Practical and Commercial Course.
GARDENING. How to Get the Most out of a Minimum of Land. Gardening for Pleasure and Profit. Market Gardening.

GROUP 2.

Art. Architecture. Glass. Earthenware. Carving.

ART. Theory and Training. Painting. Sculpture. Architecture (Theory. Styles. Practical Training). History and Ideals of Art.
GLASS AND EARTHENWARE. Including Pottery.
CARVING. Wood. Bone. Ivory. Horn. Tortoiseshell.

GROUP 3.

Biology. Psychology. Sociology. Logic. Philosophy. Religion.

BIOLOGY. Including Evolution, Palæontology, Heredity, Anthropology, Ethnology.
PSYCHOLOGY. Including Psychical Research.
SOCIOLOGY. Including Political Economy.
LOGIC. The Science of Reasoning.
PHILOSOPHY. Systems of Thought.
RELIGION. History and Systems. Christianity.

GROUP 4.

Building. Cabinet Making. Upholstering. Fire.

BUILDING. Excavating. Drainage. Manufacture of Bricks, Limes, and Cements. Bricklaying. Clay Wares. Reinforced Concrete. Masonry. Carpentry. Slates and Tiles. Plumbing. Joinery. Foundry and Smiths' Work. Painting, Paperhanging and Glazing, Heating, Lighting, and Ventilation. Building Regulations. Quantity Surveying. Building Abroad. In Business as a Builder.
CABINET MAKING AND UPHOLSTERING. A Practical Course.
FIRE. Fireproof Materials. Fire Prevention. Fire Extinction.

GROUP 5.

Chemistry and Applied Chemistry.

CHEMISTRY. Inorganic and Organic. Chemistry of the Stars.
APPLIED CHEMISTRY. Acids and Alkalies. Oils (Fixed Oils and Fats; Waxes; Essential Oils and Perfumes; Paints and Polishes). Candles. Soaps. Glycerin. Glues and Adhesives. Starches. Inks. Tar and Wood Distillation. Matches. Celluloid. Manure. Waste Products. Petroleum. Paper Making (including Paper Staining and Uses of Paper). Photography.

GROUP 6.

Civil Service. Army and Navy.

CIVIL SERVICE. Municipal. National. Imperial.
ARMY AND NAVY. How to Enter Them.

GROUP 7.

Clerkship and the Professions.

CLERKSHIP AND ACCOUNTANCY. Complete Training. Bookkeeping.
BANKING. The Whole Practice of Banking.
INSURANCE. Life, Fire, Accident, Marine.
AUCTIONEERING AND VALUING. Practical Training.
ESTATE AGENCY. Departments and Officials of a Great Estate. Training a Land Agent.
MEDICINE. Training of a Doctor. Specialists. Veterinary Surgeons. Dentistry: The Dental Mechanic. Home and Professional Nursing.
CHURCH. How to Enter the Ministry of all Denominations.
SCHOLASTIC. Teachers. Professorships. Governesses. Coaches. Tutors.
SECRETARIES, etc. Institution Officials. Political Organisations. Lecturers.
LAW. Solicitors and Barristers. Personal and Commercial Law. Copyright.

GROUP 8.

Drawing and Design.

DRAWING. Freehand. Object. Geometrical. Brush. Memory. Light and Shade.
TECHNICAL DRAWING. For Engineers; Coppersmiths, Tinmen, Boilermakers; Architects; Stonemasons; Carpenters and Joiners; Plumbers.
DESIGN. Book Decoration. Illumination. Textiles. Wall Papers and Stencilling.

GROUP 9.

Dress.

DRESS. Dressmaking. Underclothing. Children's Clothing. Tailoring. Millinery. Men's Hats. Furs and Furriers. Feathers. Shirts and Collars.

GROUP 10.

Electricity.

ELECTRICITY. Electrical Engineering. Telegraphs and Telephones (including operation of). Cables and Insulated Wire. In Business as an Electrical Engineer.

GROUP 11.

Civil Engineering.

CIVIL ENGINEERING. Surveying. Varieties of Construction. Machines Employed. Roads. Bridges. Railways and Tramways. Water Supply. Sewerage. Refuse. Hydraulics. Pumps. Harbours. Docks. Lighthouses. Foreign Work. In Business as a Civil Engineer.

GROUP 12.

Mechanical Engineering. Military Engineering. Arms & Ammunition.

MECHANICAL ENGINEERING. Applied Mechanics. Workshop Practice. Tools (Hand and Miscellaneous. Machine Tools. Portable Machine Tools). Machines and Appliances (A General Guide to Construction). Clocks and Watches. Scientific Instruments.
MILITARY ENGINEERING. Pontoons. Bridges. Fortifications. Rafts. Trenches. Passing Rivers. Conditions in Peace and War.
ARMS AND AMMUNITION. Manufacture of Arms and Explosives.

GROUP 13.

Geography. Astronomy.

GEOGRAPHY. Physical. Political. Human. Commercial.
ASTRONOMY. A Survey of the Solar System.

GROUP 14.

Geology. Mining. Metals and Minerals. Gas.

GEOLOGY. The Making of the Earth.
MINING. The Practice of Mining: Coal, Gold, Diamonds, Tin, etc.
METALS. Metallurgy. Iron and Steel. Iron and Steel Manufactures. Metal Work. Cutlery.
MINERALS. Mineralogy. Properties of Minerals.
GAS. Manufacture of Gas.

GROUP 15.

History.

A Short History of the World from the Beginning.

GROUP 16.

Housekeeping and Food Supply.

SERVANTS. Qualifications and Duties of Every Kind of Servant.
COOKERY. A Practical Course, with Recipes.
LAUNDRY WORK. Washing. The Laundry as a Business.
FOODS AND BEVERAGES. Milling. Bread-making. Biscuits and Confectionery. Sugar. Condiments. Fruit. Fisheries. Food Preservation. Catering. Brewing. Wines and Ciders. Mineral Waters. Tea. Coffee. Chocolate. Cocoa.

GROUP 17.

Ideas. Patents. Applied Education.

IDEAS. The Power of Ideas in Life. Brains in Business.
PATENTS AND INVENTIONS. How to Protect an Idea.
APPLIED EDUCATION. Application of Education in Daily Life. Finance

GROUP 18.

Languages.

How to Study a Language. Courses in Latin, English, French, German, Spanish, Italian, Esperanto, Greek. A Table of Root Words.

GROUP 19.

Literature. Journalism. Printing. Publishing. Libraries.

LITERATURE. A Survey of the World's Great Books and their Writers. Poetry. Classics. Fiction. Miscellaneous. How to Read and Write.
JOURNALISM. A Guide to Newspaper Work, with Practical Training.
PRINTING. Composing by Hand and Machine. Type Cutting and Founding. Engraving and Blocks. Bookbinding and Publishing.
LIBRARIES. Officials and Management of Libraries.

GROUP 20

Materials and Structures. Leather. Wood Working.

MATERIALS. The Characteristics and Strength of Materials.
STRUCTURES. The Stability of Structures.
LEATHER. Leather Industry. Leather Belts. Boots and Shoes. Saddlery and Harness. Gloves. Sundry Leather Goods.
WOOD WORKING. Design and Operation of Wood Working Machinery. Wood Turning. Miscellaneous Woodwork.

GROUP 21.

Mathematics.

MATHEMATICS. Arithmetic. Algebra. Geometry. Plane Trigonometry. Conic Sections.

GROUP 22.

Music. Singing. Amusement.

MUSIC. Musical Theory. Tonic Solfa. Tuition in all Instruments. Orchestration. Conducting. Bell Ringing. Manufacture of Musical Instruments.
SINGING. The Voice and Its Treatment.
AMUSEMENT. Drama and Stage, including Elocution. Business side of Amusement. Sports Officials.

GROUP 23.

Natural History. Applied Botany. Bacteriology. Natural Products.

NATURAL HISTORY. Botany: Kingdom of Nature—its Marvels, Mechanism, and Romance; Flowers, Plants, Seeds, Trees, Ferns, Mosses, etc. Zoology: Animals, Birds, Fishes, Reptiles, Insects.
APPLIED BOTANY. Tobacco & Tobacco Pipes. Forestry. Rubber and Gutta Percha. Basket Making. Cork, Wattle. Cane Work. Barks. Brush Making.
BACTERIOLOGY. Pathological and Economic.
NATURAL PRODUCTS. Sources. Values. Cultivation.

GROUP 24.

Physics. Power. Prime Movers.

PHYSICS. A Complete Course in the Science of Matter and Motion.
POWER. A General Survey of Power. Natural Sources. Liquid and Compressed Air.
PRIME MOVERS. Engines. Steam. Gas. Heat. Turbines. Windmills.

GROUP 25.

Physiology. Health. Ill-health.

PHYSIOLOGY. Plan of the Body. Digestive. Circulatory. Respiratory, Locomotor and Nervous Systems. The Senses.
HEALTH. The Five Laws of Health. Personal Hygiene. Environment. State Medicine and the Public Health.
ILL-HEALTH. General Ill-health. Its Special Forms. Common Ailments and Domestic Remedies.

GROUP 26.

Shopkeeping. Business Management. Publicity.

SHOPKEEPING. A Practical Guide to the Keeping of all Kinds of Shops.
BUSINESS MANAGEMENT. The Application of System in Business.
PUBLICITY. Advertising from all Points of View. As a Business.

GROUP 27.

Shorthand and Typewriting.

SHORTHAND. Taught by Pitmans.
TYPEWRITING. Working and Management of all Machines.

GROUP 28.

Textiles and Dyeing.

TEXTILES. The Textile Trades from Beginning to End.
DYEING. Dyes and Their Application.

GROUP 29.

Travel and Transit.

TRAVEL. How to See the World. The Business Side of Travel.
TRANSIT. A General Survey of Means of Communication.
VEHICLES. Construction of Air, Land and Sea Vehicles. Business of a Liveryman, Carrier, etc. Driving.
RAILWAYS. The Management and Control of Railways.
SHIPS. Shipbuilding. Shipping. Management of Ships.

EVERY · DOOR · IS · BARR'D · WITH · GOLD · AND · OPENS · BUT · TO · GOLDEN · KEYS

HARMSWORTH SELF-EDUCATOR

A · GOLDEN · KEY TO · SUCCESS · IN · LIFE

EDITED · BY · ARTHUR · MEE.

1907 VOLUME VII 1907

CARMELITE HOUSE. LONDON. ENGLAND.

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MOULDING AND FIRING CLAY

Manipulation of the Clay. Biscuit Ovens and Biscuit Firing. How Glaze is Prepared and Applied to Biscuit Ware

continued from page 5162

By MARK SOLON

THE moulding of the clay into the various forms required may be done in a great many ways, according to the shape and size of the piece.

Throwing. The most ancient method, and one still in use, is by means of a *thrower's wheel*, a modern type of which is shown in **8**. The thrower sits over the revolving disc, A, into the centre of which he throws the piece of clay. By pressing the sides or the top of the mass while in motion he raises or depresses it, or may hollow it out by the pressure of his fingers, making any regular circular shape he wishes.

The speed at which the disc is driven is regulated by the movable driving cone B, which is actuated by the lever C. The operator, by working the lever alters the pitch of the driving cone B, bringing a larger or smaller driving surface to bear upon the cone D; thus, by pressing down the lever the base of the driving cone is brought into contact with the apex of the cone D, increasing the speed of the disc, and by reversing the movement the speed is accordingly decreased. The cone B is driven by a rope passing round the pulley E.

The operator regulates the machine to the size of the piece he is throwing, decreasing the speed for the larger pieces and accelerating it for the smaller.

Turning. After the rough form has been *thrown*, it is placed in a heated chamber and allowed to dry until sufficiently hard to handle. It is then finished, and the accurate shape given to it on a turner's lathe [**9**]. This lathe is similar to that employed by a wood-turner. The pieces are fixed upon the horizontal spindle, A, in the manner shown in the diagram, the mouth of the article being forced on to a wooden cone. When set in motion the superfluous clay is cut away with small steel tools and the piece turned to the correct shape. The spindle is then made to revolve in the opposite direction and the surface of the clay polished with flat pieces of steel.

The other processes of moulding the clay and those most extensively used are *pressing*, by machine and by hand, and *casting*.

Machine Pressing. The *pressing* of plates is perhaps the simplest form of mechanical pressing, the machine being called a *flat jigger* [**10**, A]. It consists of a revolving spindle to the head of which is attached an iron frame or ring; on this ring is placed the plaster mould, which is an exact replica in plaster of Paris of the inside of the plate. Working in conjunction with the flat jigger is a *batting machine* [**10**, B], which mechanically prepares the slab or bat of clay with which the plate is to be made. It consists of a revolving spindle, upon which is fixed a round plaster block, B [see diagram **10**, B]; the piece of clay is thrown into the centre of the block, which is put in motion; the steel "spreader," C, then descends, flattening out the clay to the proper size and thickness.

The workman places the bat of clay upon the mould and puts the latter on to the ring, D [see diagram **10**, B], which forms the head of the jigger.

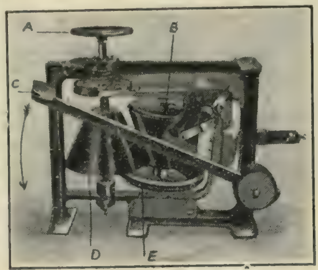
A steel profile, A, which works upon a hinge, is brought to bear upon the clay, pressing it against the mould and at the same time giving the shape to the back of the plate. The mould, with the shaped piece of clay upon it, is put into a heated chamber and dried. The face of the plate is afterwards polished with fine sandpaper and the edges rounded with small steel tools.

Jollying. Another form of machine pressing is known as *jollying*, and is employed in the production of circular hollow pieces. In this case the plaster mould forms the outside of the article and the steel profile the inside. The machine [**11**] is of similar construction to the flat jigger. The head, however, is in the form of a metal cup, and the mechanical arrangement for introducing the profile is different. The mould is made in two parts, which are held together by an outer plaster frame. This frame fits accurately into the hollow metal head of the machine.

After the slab of clay has been formed by a batting machine as already described, it is roughly shaped upon a circular block of plaster which is covered by a loose flannel cap. The block, with the clay upon it, is inverted into the hollow mould, and on being withdrawn leaves the shaped piece of clay resting within the mould. The machine is then set in motion, and the operator with the wet sponge presses the clay against the mould, expelling the air from between them; the steel profile is then introduced, which gives the correct shape and finish to the inside of the piece.

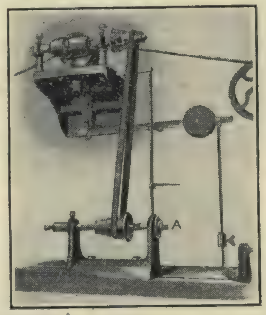
Hand Pressing. The foregoing processes only apply to circular shapes; square and irregular pieces must be pressed by hand. If we take as an example of this method an ordinary jug, the mould is made in two pieces [**13**]. Flat slabs or *bats* of clay are beaten out by the workmen upon a plaster block, with a mallet of the same material, and placed upon the mould; the clay is then pressed against the mould by means of wet sponges and flat pieces of india-rubber. Both sides of the mould having been lined in this way with clay, the two halves are put together and the seam between them filled in with a small roll of plastic clay. The handle of the jug is pressed from a solid roll of clay between two plaster moulds. After

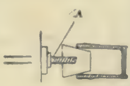
being partially dried, it is fitted to the shape of the jug, the ends are dipped into thick slip, placed in position on the jug, and by gentle pressure made to adhere. After drying, the rough edges are trimmed with a knife, and the surface finished with fine moist sponges.



8. THROWER'S WHEEL

Casting. In the process of casting, instead of using the plastic clay we take the slip before the superfluous water has been filtered from it. This method is resorted to when either very thin or highly ornamented pieces of intricate shape are required. Having taken the hollow plaster mould, which is naturally extremely absorbent, it is filled with slip. Immediately, the plaster absorbs the water from the slip which comes in contact with it, coating the mould with a thin film of clay; the superfluous slip is then emptied from the mould, the clay piece remaining in it until hard enough to remove. After drying, it is finished in the usual way with moist camel-hair brushes and fine sponges.





9. TURNER'S LATHE

Reference has been made to plaster moulds upon which depend the shape and modelled ornamentation of pressed or cast pieces. These moulds, which are made of plaster on account of the ease with which it can be manipulated and its power of absorbing water, are cast successively from clay or plaster model by pouring the liquid plaster (plaster mixed with water) round the model, and allowing it to set. In this way the ornamentation or relief worked upon the original can be reproduced in any quantity.

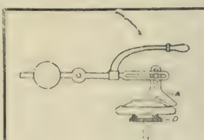
Drying. After the clay has been moulded by any of the foregoing methods the pieces are hardened by *drying*, so that they may be safely handled for finishing. In other words, the water, which to a large extent has been artificially introduced to aid plasticity, is driven off. This brings about a diminution in the bulk of the clay, which is called contraction or shrinkage.

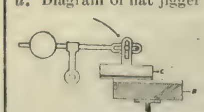
In each workshop is built a stove, or drying chamber, heated from the floor by means of steam pipes. The interior of the chamber is fitted with shelves upon which the moulds are put. When a large number of moulds are used, as in the case of plate and saucer making, the shelves are arranged upon an upright spindle, which revolves inside the stove [12]. The shelves are constructed in distinct sections, which, on turning the spindle, present themselves in rotation at the opening of the stove. In this way only one section at a time is exposed in the workshop, and this, when filled with moulds, is turned into the heated chamber. The shelves are thus filled and emptied continuously, the time taken for each revolution of the spindle being sufficient to dry the clay thoroughly.

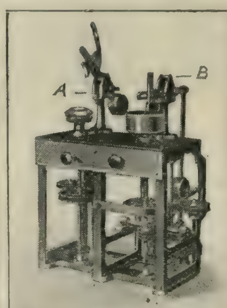
It is necessary in drying that the evaporation of water should take place evenly and slowly, otherwise the clay will have a tendency to twist and crack, giving way always in the weakest part. The speed with which the drying may safely proceed depends upon the amount of water to be expelled, or the extent to which the body is liable to contract. This varies according to the proportion of plastic materials it contains. The higher the proportion the greater the contraction, and consequently the more slowly and carefully must the piece be dried.

Biscuit Firing. We come now to the most difficult and important process in pottery manufacture—*biscuit firing*, or hardening of the clay in order to make it durable and capable of being glazed. This hardening, or vitrification, is characterised by a further contraction due to the chemical combination of the ingredients in the body under the influence of heat. In order to raise the clay to the desired temperature, furnaces, or *biscuit ovens*, as they are called, are built, capable of holding a considerable quantity of ware. The construction of these ovens varies considerably, but the simplest forms, and those generally adopted, are the *up-draught* and *Minton's Patent*. We must bear in mind in studying the construction of these ovens that the main object is the uniform and economical distribution of heat through the entire mass.

The Up-draught Oven. The up-draught oven [14] consists of a circular chamber round


a. Diagram of flat jigger


b. Diagram of batting machine



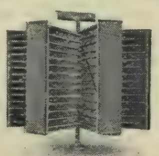
10. PRESSING AND BATTING MACHINE
(W. Boulton, Ltd., Burslem)

the base of which are from 8 to 12 fire holes or mouths. The chamber is built within a large conical chimney. On leaving the mouths, the fire ascends through the oven by upright

and horizontal flues; the former serve to heat the outside circumference, while the latter convey the flame to the centre. The products of combustion from both escape through holes in the dome top. The fires are fed with coal through openings at the top of the mouths.

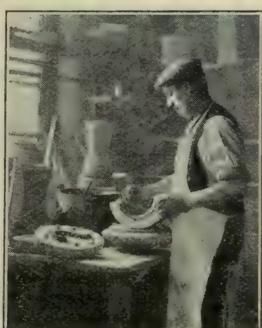
These openings are fitted with iron doors or fireclay slabs, which, being entirely or partially closed, regulate the amount of air passing into the oven.

The Down-draught Oven. The Minton's Patent, or *down-draught* oven [15], differs considerably from the up-draught in construction and principle. The general arrangement of the fire holes is the same, but it will be noticed that there is no independent chimney or hovel, the chimney being built upon the body of the oven itself. The great difference in principle, however, is the course taken by the flame. The fire holes are connected with the interior of the oven by upright flues only; on leaving these flues, the flame ascends to the top of the dome. The opening, A, however, being closed, the products of combustion are reflected to the floor, and, passing through holes in the bottom of the oven, B, escape eventually by the vertical flues, C, built in the walls. The course taken by the flame in this case is much more lengthy than in the case of the up-draught oven, and results in more perfect combustion and consequent economy of fuel.



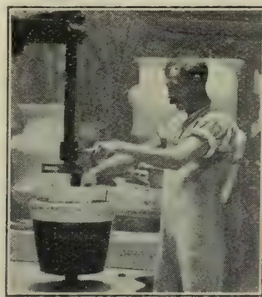
12. REVOLVING SPINDLE FOR DRYING MOULDS

The Saggers. Having briefly described the construction of the oven, we will pass on to the method in which the clay ware, already dried, is placed in the inner chamber and fired. In order to protect the clay from the fire, and also so that the oven can be properly filled, the pieces are first of all put into fireclay boxes, or *saggers*. These saggers are made from coarse local marls which occur in the coal districts, and are of size and shape to suit the particular class of goods for which they are intended. The marl, after being mined from the pit, is crushed between metal rollers and mixed in a horizontal pug mill with about a third of its weight of previously fired marl, the requisite amount of water being added to make the mixture plastic. In practice, the saggers, which have already been fired and become useless or broken, are ground up and used to mix with the marl. The object of introducing the fired material is to reduce the contraction and enable the saggers to withstand sudden changes of temperature when the oven is cooling. Up to recently, these saggers have been almost universally made by hand, but latterly machines have been designed which, although not perfect, will doubtless eventually supersede the hand methods



13. JUG-MAKING

The prepared marl is first of all beaten by hand with wooden mallets on an iron table into flat sheets of about 1 in. thickness. The sheets are then cut with a knife into strips, the width of the strip corresponding to the height of the sagger required. The shape is given by wrapping these strips round wooden boxes or drums, which are afterward placed upon flat bats of marl the size and shape of the bottom of the sagger. The strips which form the sides are then worked into and welded to the bottom, thus forming a complete box; these are then slowly dried and sent to the oven to be fired.



11. JOLLYING
(Boulton & Co., Ltd., Burslem)

Filling the Oven. The clay ware is simply placed inside the saggers, packed as closely as possible, clean sand being used to support it where necessary. The saggers are arranged one upon the other in the oven as shown in **18**, those containing such pieces as ewers, jugs, cups, and the majority of small hollow ware being placed in the hottest parts of the oven, while the plates, dishes, etc., are kept in the centre, away from the fire holes. After the entire oven has been filled as solidly as possible with saggers, the entrance is built up and made airtight.

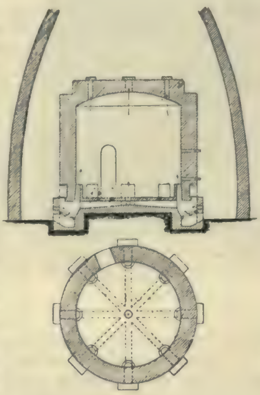
Firing the Biscuit Oven. The firing, as we have already said, must proceed slowly and evenly, our object being to raise the entire mass in the oven to one uniform heat, and to bring about the contraction of the clay equally and continuously. The time taken to fire a biscuit oven is from 48 hours to 60 hours, and may be divided into three stages.

During the first stage, or *smoking*, the fires are very slight, as it is only necessary to create a gentle heat in the oven just sufficient to drive off any free moisture which may have remained in the ware or unfired saggers. This treatment lasts for about twelve hours, until the whole of the oven is thoroughly warmed.

During the second stage the heat is gradually raised for about 24 hours. The clays now lose their combined water, which is driven off at about red heat. The body, however, does not undergo any marked change, and remains about the same size, but losing a little of its density. Great care must be taken not to increase the heat too rapidly, otherwise the outer part of the oven will become very much hotter than the centre, a difference which cannot afterwards be rectified

The third stage, which we might consider as the firing proper, begins with the contraction of the body. The fireman controlling the oven must then be guided by whatever pyrometer he is using as to the correct manner to treat his fires in order to bring about the entire shrinkage in an even and regular manner.

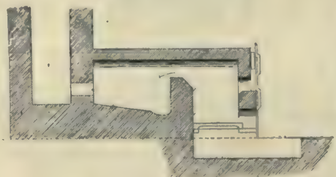
Pyrometers. The *pyrometers*, on which depend, to a great extent, the ultimate result of the firing, may be divided into two classes—those indicating the heat acquired, and those showing the effect of the heat on the material.



14. UP-DRAUGHT BISCUIT OVEN

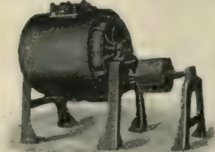
Of the first class, the "Seger cones" are the most generally used and the most reliable. They are composed of more or less fusible felspathic mixtures so adjusted that they bend or melt at given temperatures. Having placed a number of them in the sight holes of the oven, the fireman, by making periodical observations, sees exactly what heat he has attained.

In the second class, the actual material being fired is used. Small pieces of the dried body, or "trials," are put in the oven as before, but arranged in such a way that they can be easily drawn out and examined. The fireman then judges the heat by measuring the contraction of the trials or by observing the texture of the fracture when the piece is broken. The latter method is extensively used. By allowing the small pieces to cool very quickly, they split. The denser the body, the closer the particles; consequently, the smoother the fracture. The appearance of this fracture becomes then an indication of the density of the body, or of the heat to which it has been submitted.



16. FRITTING FURNACE

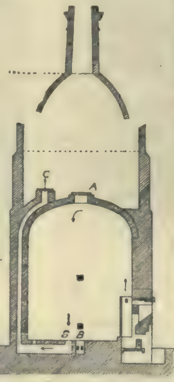
The second class is undoubtedly the more reliable one, as the increase in heat does not always correspond with the molecular work done in the body. There are certain periods during the firing when chemical combinations take place in the body which bring about the shrinkage, so that, in order that the contraction of the ware should occur evenly, the heat at these periods must be to a certain extent withheld.

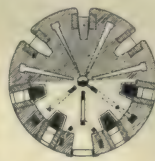


17. ALSING CYLINDER

After the right temperature has been reached, the oven is allowed to cool slowly.

Should the cooling proceed too rapidly, the larger and thicker pieces of ware will have a tendency to split, the outside of the piece becoming cold while the centre is still hot, and causing an unequal contraction. When the whole of the oven has become thoroughly cool, the ware is drawn out and examined, and the faulty pieces, such as the cracked and twisted, are separated from the good. The body is now in the biscuit state, having been thoroughly hardened by the fire, but in the case of the mixture under consideration, still retaining a little porosity.





15. MINTON'S PATENT OR DOWN-DRAUGHT BISCUIT OVEN

Glazing. The foundation of all glazes is the silica or flint rendered fusible by the addition of fluxes, such as borax, carbonate or oxide of lead, lime, soda, and potash. These materials, mixed in suitable proportions and melted together, produce a glass which harmonises with the biscuit to which it is applied.

Equal Contraction and Expansion. It is particularly necessary that the glaze should be so composed that it has a similar contraction and expansion to the body which it covers. The glaze, like the body, expands with heat and contracts with cold, and unless the body and glaze contract and expand simultaneously, two faults are developed. In the first place, should the glaze contract on cooling more than the body, it breaks up, the surface becoming covered with fine cracks or *crazes*. If, on the other hand, the body contracts more than the glaze, it is apt to compress the glaze, which, after it has been compressed beyond the limit of its elasticity, acquires sufficient pressure to break the piece.

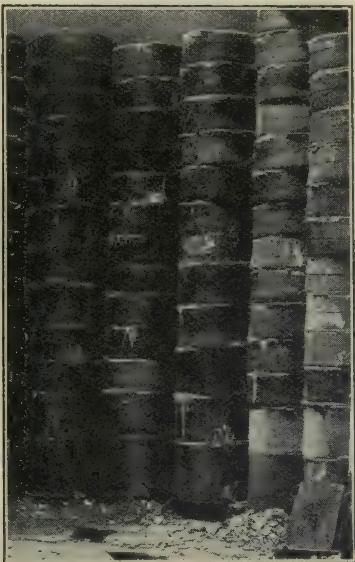
The peculiar properties of the various fluxes used in combination with the flint are as follows:

The *borax* gives brilliancy and hardness to the glaze, and has the property of covering a large surface in proportion to its weight. The *lead* makes the glass elastic and lustrous, and at the same time forms a more stable glass, which is not so easily affected by subsequent repeated fires. The lime is introduced for its stability and transparency when in combination with the silica and borax. *Soda* and *potash* are the most fusible fluxes, and greatly affect the melting point of the glaze.

It must be borne in mind that these properties are due to the *combination* of the ingredients and to their effect upon one another when melting.

Preparation of the Glaze. Our object now is to produce a mixture from the above materials which, when ground to a finely divided state, shall be stable, and in no way soluble in water. However, certain of the ingredients necessary for the glass, such as borax, soda and potash, are extremely soluble in water, and the first process in glaze-making is to render them insoluble by combining them with certain proportions of silica, Cornish stone, lime, china clay, etc. This is done by intimately mixing together the materials and melting them in a specially constructed furnace [16]. This process is called *fritting*, and the glass so produced the *frit*. A further quantity of flint, lead, and stone is then added to the frit, and the whole mixture ground in water.

The mill already described has, till recently, been used for glaze grinding, but it has now been superseded by the "Alsing cylinder," a rotary mill [17]. This machine takes considerably less power to drive, and grinds more rapidly. It consists of a cylinder lined with chert porcelain, or wood, which is half filled with small flint boulders. The frit and mixture is introduced into the cylinder with a certain amount of water. On making the cylinder revolve slowly the flints rub against each other, and the glaze lying between and about the boulders is ground by the friction between their surfaces. After it has been passed through fine silk sieves, and the metallic iron extracted from it by ordinary magnets, the liquid glaze is delivered into tanks.

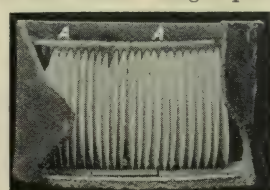


18. METHOD OF ARRANGING SAGGERS IN BISCUIT OVEN

Applying the Glaze to the Ware. The liquid glaze is applied to the ware by plunging the porous pieces of biscuit into the liquid, the porousness ensuring the retention of a sufficiently thick coating. The evenness of the coating depends upon the manner in which the piece is dipped into the liquid and the superfluous glaze shaken from it.

After being thoroughly dried, the ware is again placed in saggers, which are built up in the oven in the manner already described for biscuit firing, with the exception that the joint between every sagger is made airtight by the insertion of rolls of plastic clay.

The method of placing the ware, however, is different, as the pieces must be kept from contact with one another or with the sagger, to prevent the glaze, when molten, causing them to adhere.



19. PLATES ARRANGED FOR GLOST FIRING *a*. Thimbles

To accomplish this the articles are separated by various shaped small pottery supports called *thimbles*, *stilts* and *saddles*. Fig. 19 shows the arrangement for placing plates or saucers, the thimbles, A, being so formed that they can be built up one on another, so that the ware only comes into contact with the pointed arm.

After the glaze has been cleaned from the foot, hollow pieces, such as jugs, cups, ewers, etc., are placed on the bottom of the sagger, upon which some small flint chippings have been previously strewn. These chippings provide small pointed supports for the pieces, and so prevent them from adhering to the bottom of the sagger.

The composition of the glaze suitable for the body given at the beginning of this article is as follows:

Frit—	
Borax	30
Flint	18
Stone	18
Whiting	10
China Clay	8
Carbonate of lead	16
Mixture to mill—	
Frit	55
Stone	32
Flint	5
Carbonate of lead	8

Glost Firing. The *glost firing*, or remelting of the glaze upon the surface of the biscuit, must proceed briskly, and occupy from about 18 to 24 hours. The fireman gauges the progress of the heat by drawing from the oven periodically small rings, or trials, made of a lightly fired red marl and dipped in a soft-red glaze, which darken as the heat increases. It is extremely important during the whole process of glost firing that the atmosphere inside the oven should be kept as oxidising as possible. In other words, if insufficient air for combustion be admitted through the fire holes, the products of combustion become laden with carbon, which, in order to burn, will rob the lead and other compounds in the glaze of their oxygen and so affect the brilliancy of the piece. For this reason the ovens are cooled very quickly, allowing as much air as possible to pass through the oven while the glaze is still in the molten state. It must be understood that the brilliancy of the glaze on the ware depends to a very great extent upon the oxygen which is contained in the fluxes.

When it has been drawn from the oven the ware is carefully examined for faults, the small rough places, where each piece has been supported during firing, being dressed and smoothed with steel tools.

Continued

NAPOLEON

A Short Story of a Great Career. Napoleon's Triumphs and his Fall. The Restoration of the Bourbons. France Again Under a Republic

By JUSTIN McCARTHY

THE movement of the great French Revolution was brought to a close, for a time at least, by the career of Napoleon Bonaparte. Napoleon may be ranked as soldier, conqueror, and dictator even with Julius Cæsar, although he had none of Cæsar's gifts as historian, orator, and statesman. He came of an ancient Corsican family, and was born at Ajaccio, August 15th, 1769. When ten years old, he was sent to a military academy, and five years afterwards was removed to a school of the same order in Paris. He entered soon after a regiment of artillery as second lieutenant. His rise was so rapid that in February, 1796, he was appointed General in command of the army in Italy, which had then for its chief enemies the forces of Austria.

He won many victories over the Austrians and Piedmontese, and at the famous battle of Lodi gained a complete victory over the Austrian forces, and entered Milan in triumph. The contest, however, was still continued with great obstinacy on the part of the Austrians. The great European powers now began to regard Napoleon as the enemy of all states and sovereignties outside France, and alliances were formed against his ambition and genius. Napoleon soon had arrayed against him the armies of Austria, Prussia, and Russia, and it was becoming evident that before long England would join the coalition. His expedition to Egypt began in May, 1798, and he accomplished the capture of Cairo in July. His fleet, however, was destroyed on August 1st by Nelson at the battle of the Nile.

Peace Overtures. There were domestic troubles in France meantime, and Bonaparte returned to take part in forming a new constitution. With some other leading Frenchmen, he established a new constitution, under which the Government of the country was invested in three Consuls. Napoleon was nominated First Consul for ten years. He now made overtures for peace to England and to Austria, and he endeavoured to convince these Governments that he was a sincere friend of peace. It is contended by some English writers that if Bonaparte's overtures had been accepted, an abiding peace might have been won for Europe

France was still profoundly influenced by resentment for the attitude which most of the European monarchial states had adopted towards the French Revolution, and she believed she had reason to regard Europe in general as her enemy. Napoleon took command of an army, which he led through Switzerland, across the St. Bernard, into Italy; he occupied Milan, and defeated the Austrians at the battle of Marengo. Austria offered terms of peace by giving up the greater part of North Italy; a treaty with Germany followed in February, 1801, and the Treaty of Amiens, with England, in 1802 Napoleon was then elected First Consul for life, and set himself to work for the reconstruction of the whole civil constitution of France. She was, however, no nearer to peace than she had been before. Napoleon was possessed by the conviction that England felt for him an irreconcilable enmity, and the English believed that Napoleon was planning some treacherous attack upon them.

Three Great Battles. On May 18th, 1804, Napoleon assumed the title of Emperor of the French, and it soon became evident that a great European war was at hand. Napoleon appears at one time to have been maturing a plan for the invasion of England, but her naval superiority made this design futile, and he led his armies through Hanover, won a great victory over the Austrians at Ulm on October 15th, 1805, and on December 2nd following he won the great victory at Austerlitz over the allied Russians and Austrians. He had, during this campaign, inflicted defeats on the Prussian Army. Prussia, however, still held out, and got together a new army; but it was to little purpose, for Napoleon won another great victory at Jena. At last a peace was made by which Prussia had to surrender nearly half her territory. Napoleon sent an army into Portugal under General Junot, and another to Spain under Murat, who captured Madrid.

Napoleon made his brother, Joseph, King of Spain. Joseph had already been created by him King of Naples, but Napoleon thought it now more fitting to transfer him to the rulership of the defeated Spaniards. The Spaniards kept up a continuous rebellion, against which Joseph, who was a kindly-hearted and humane man, found himself unable to contend, and he soon withdrew from the troubles of Royalty to a life of peace.

The Retreat from Moscow. Napoleon endeavoured to carry on his conquests, but a new figure had arisen on the scene in the person of Arthur Wellesley, afterwards Duke of Wellington. He began by defeating Junot and other of Napoleon's marshals, and the event marked the opening of a change in his career. He took a fatal step by invading Russia with an army of 600,000 men, because it would not assent to his annexation of Holland and Westphalia. He won his first battle, which he followed up by taking possession of the city of Moscow. Here he met with unexpected resistance, for a vast fire broke out, destroying the greater part of the city and rendering a retreat unavoidable. The retreat from Moscow was one of his greatest disasters—it was the beginning of the end.

Napoleon returned to Paris to raise a new army, but the day of his greatness was over. He received a crushing defeat at Leipzig, and then began the invasion of France by the Allies. Wellington was now leading his army across the Pyrenees, and Napoleon, feeling that the game was over—at any rate, for the time—offered to abdicate in favour of his son. The offer, however, was not accepted, and he was compelled to make an unconditional abdication.

The Allies offered to confer upon him, on condition of his withdrawal from France, an empire of a somewhat diminutive order. He was to be created sovereign of Elba, with the title of Emperor. This arrangement Napoleon accepted on April 5th, 1814, as he had at the time no means of resisting. Outside France, he had aroused all Europe against him, and his enemies had him in their power. He had, therefore, to accept terms which practically made him an exile. But he soon began to make secret arrangements for a return to the scene of his Imperial power. He escaped from Elba with some followers in a little fleet of hired vessels, landed in France on March 1st, 1815, and received a rapturous welcome throughout the country, the army receiving him with undivided enthusiasm. The Empire was restored as by magic, and Napoleon once more entered Paris in triumph at the head of his army.

Waterloo. The coalition against him had in the meantime become relaxed in its cohesiveness, and when Napoleon returned to France, only a mixed force in Belgium under Wellington and a Prussian army commanded by Blucher, along the Rhine, were ready to oppose him. Napoleon gained a victory over Blucher, but lost some time before following it up. Napoleon then led his forces to attack Wellington, who had already defeated, at different times, most of the Emperor's ablest marshals, and he now had the advantage owing to Napoleon's want of promptitude in a decisive movement. With the help of the Prussians, who had joined him, Wellington won a complete and crushing victory over Napoleon on the Plains of Waterloo.

Napoleon, knowing that his last hopes were gone, fled to Paris, and, with the intention of seeking refuge in America, went to Rochefort; but, either changing his purpose or finding the project impracticable, he gave himself up as a prisoner to the captain of the British war vessel, the Bellerophon, and was brought to England, and from thence banished by the British Government to St. Helena. He arrived on October 15th, 1815, and there he spent the remainder of his life.

The Restoration of the Bourbons. When Napoleon left Paris after the defeat at Waterloo, Louis XVIII. entered it, and the family of the Bourbons was restored for the time to the throne. A decree was passed excluding for ever all members of the Bonaparte family from France Louis XVIII. died in 1824, and was succeeded by Charles X., who distinguished himself only by his efforts to restore the absolute system of the old French monarchy. But the principles of the Revolution had spread too widely and deeply among the French people to admit of any return to the ancient systems. The settlement made at the Congress of Vienna by the victorious European sovereigns, with the object of maintaining the old-fashioned system of monarchy, was made with no regard to the development of human intelligence, the spread of education, and national sentiment. Charles X. tried to maintain his power by passing the Proclamation of Ordinances, announcing a new system of elections, restricting liberty of speech and publication, and abolishing the charter which the Bourbon family consented to accept on their restoration. The King also dissolved the Parliament which had but recently been elected as a protest against the tyrannical measures he was introducing. The result was that the people of Paris rose in armed resistance, and the King had no course left than to abdicate—on August 3rd, 1830. He died in exile.

Louis Philippe. Louis Philippe, the eldest son of the Duke of Orleans, was born on October 6th, 1773. When the revolution broke out and the Republic was established, he and his father joined the popular movement. He served in the wars of the Republic, but soon got into political trouble, and sought refuge in Austria, and afterwards in Switzerland, where he made a living as a teacher. He spent some years in the United States, and afterwards settled near London. On the restoration of the sovereignty in France, he was enabled to recover his estates, and on the abdication of Charles X. was raised to the crown. He was popular for a while, because he was believed to be a constitutional sovereign; but he disappointed popular expectations, and when public disappointment showed itself in constitutional fashion, he had recourse to the old measures of reaction—the dissolving of Parliaments, the suppression of hostile newspapers, the secret interference with trial by jury, and intrigues with foreign Governments. There was a rising against him in the February of 1848. He was forced to abdicate, and took refuge in England, where he died on August 26th, 1850. After his flight, a Republic was proclaimed. Among the rising figures in the new Republic was that of Louis Napoleon, the son of Louis Bonaparte, the great Emperor's brother.

Louis Napoleon. Louis Napoleon had lived in exile and had written and published some military and political treatises. By the death of the Duke of Reichstadt, only son of Napoleon I., he became the head of the family. He made two unsuccessful attempts to create a Napoleonic restoration, and for the second he was sentenced to perpetual imprisonment in the fortress of Ham. He escaped after five years and came to England. When the revolution of 1848 broke out in France, he returned, and was elected a member of the Constituent Assembly; he afterwards became a candidate for the Presidency, and was elected by an immense majority. For a time he played the part of a constitutional and republican chief magistrate, but his ambition sought a higher sphere and more complete authority, and he succeeded in obtaining the confidence of the Army. On

December 2nd, 1851, he abolished the existing constitution, so far, at least, as it prevented the creation of a dictatorship. This was an open act of military power, but it appeared to have had the support of the country, for when the vote was taken, Louis Napoleon was re-elected President for ten years by a suffrage of over seven millions.

The Empress Eugénie. He soon assumed the title of Emperor, and was again supported by the country in general. He now made it his work to recommend himself especially to the army, the democracy, and the clergy. He insisted on the right of peoples to chose their own rulers, but he imposed the severest restrictions on the liberty of the Press. On January 29th, 1853, he married Eugénie de Montijo, a Spanish countess of remarkable beauty, who made a brilliant figure at the Imperial Court, and who lived to see the fall, to share the exile, and to kneel by the grave of her husband. The policy of Napoleon throughout seems to have been directed to propitiate the popular vote and to conciliate the Army. He undoubtedly effected much good work towards the improvement of the cities and towns of France, and established Treaties of Commerce with many foreign states. The commercial treaty with England was prepared by Richard Cobden for England and by Michel Chevalier for France. He exerted all his power towards the repression of republican opinion and all independent opinion in the Press or on the platform. He formed military alliances with other European states; and with England, Sardinia and Turkey he helped to carry on the Crimean War against Russia. He also carried on a successful war against Austria, which did much towards the emancipation of Italy.

Louis Napoleon and Mexico. Most unfortunate was his attempt to convert the Republic of Mexico into an empire under the rule of the Archduke Maximilian of Austria. This began as the result of many just complaints made by the English, French, and Spanish Governments of the ill-treatment of foreigners in Mexico, and the non-payment of arrears due to foreign fund holders. The three Governments resolved to enforce their claims; but Louis Napoleon's project for the creation of an Empire in Mexico was disapproved by the English and the Spanish Governments. The French Emperor carried it on alone and the Archduke Maximilian entered Mexico as Emperor under his protection. The Mexicans held out with irrepressible resistance and the Government of the United States came to their aid, supporting this action by the terms of the famous Monroe doctrine, and Napoleon's Government found it necessary to withdraw their troops.

Maximilian carried on the resistance to his Mexican opponents, and sanctioned the execution of several Mexican generals in the service of the Republic who had maintained the cause of their country in arms. When Maximilian's attempt to found an empire thus utterly failed, he was, in his turn, tried by court-martial, ultimately condemned to death, and shot.

War with Prussia. Louis endeavoured to recover his lost prestige by finding a pretext for quarrelling with Prussia, against whom he declared war in July, 1870. That war proved the crowning failure of his policy. The Prussians won victory after victory, and at last occupied Paris, Napoleon III. being captured and held as prisoner until the settlement of that Peace which brought about the formation of a new French Republic. In March, 1871, he came over to England, and lived there with his wife at Chiselhurst, in Kent, where he died on January 9th, 1873. Their son, Eugène Louis, had served in his father's army during the fatal war of 1870, and afterwards accompanied his parents to England. He served as a volunteer with the English forces in Zululand in 1879, and lost his life in the campaign.

The new French Republic was founded under conditions which might have seemed hopelessly discouraging. The enemy was still in possession of Paris and a great part of the country; and, further, a great socialistic revolt was springing up among the French people, chiefly among the population of the cities. The Commune was actually proclaimed, and some fearful riots took place, among which several French generals who had fought for their country against the Germans, and were now fighting for the Republic against the Commune, were done to death. The Archbishop of Paris, Monseigneur Darboy, was murdered. The Communists held Paris for a time, and when this became impossible they burnt down many of the great public buildings. The Republic conquered in the end, and severe punishments were inflicted.

The New Republic. The President, M. Thiers, had to undertake with the opening of his presidency the task of concluding peace with the German invaders and bringing the civil war to an end. Both tasks were accomplished, and the Republic began its work of peaceful civil government. But even in the Constitutional Assembly there was a still strong monarchial party; indeed, two parties—one in favour of restoring the old Legitimist dynasty and the other supporting a restoration of the Orleanist dynasty. Thiers, although a monarchist at heart, maintained that a new monarchy was impossible at the time, and allied himself with the Republicans. Leon Gambetta, a great democrat and orator, who, during some of the recent troubles, had been in all but name Dictator of the country, maintained the cause of the Republic, and the Republican party had a complete victory. Thiers died during the course of the electoral struggle which decided the victory. The Third Republic was founded with a succession of elected presidents, for a fixed period of years, to be its presiding magistrates. That Republic has already lasted much longer than either of the two which preceded it, and there does not at present seem any indication that the public mind of France is likely to turn with favour again to any project for the foundation of a Monarchy or an Empire.

Continued

MANY TELEGRAMS ON ONE WIRE

Duplex and Quadruplex Working. Various Methods of Transmission. Sending Two or Four Messages Simultaneously on one Wire

Continued from page 5178

By D. H. KENNEDY

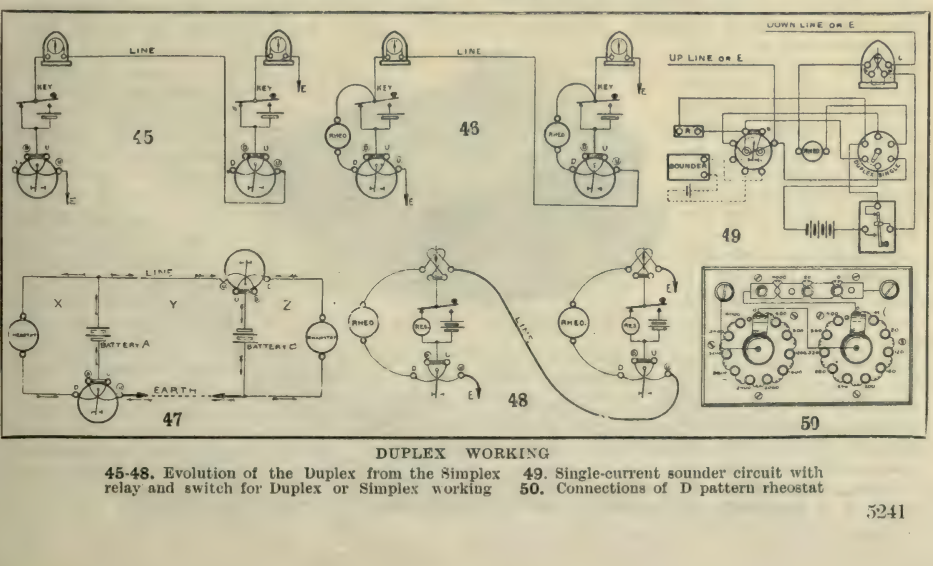
IT is safe to say that nothing excites the wonder of the young telegraphist more than duplex working, the system which enables messages to be sent simultaneously in opposite directions on a single wire. Most of the English circuits are worked on what is called the *differential system.* Let us approach the subject from familiar ground.

Consider a single-current circuit as shown in **30**, page 5067. How can we modify it so as to enable it to be used for duplex working? As we wish to be able to receive a signal at the same time as we are sending, it is clear that we must alter the position of our relay so as to include it in the line circuit. We may do this by connecting No. 3 terminal to No. 1, and No. 2 to earth. Now we find that our own signals affect our relay, and we come to the real crux of the problem—that is, how can we signal through our relay without affecting it? For this purpose the relay is arranged with differential windings. First, we must adjust the brass straps so that both are connected across between Ⓓ and U. Now rearrange the circuit connections as shown in **45**.

Duplex Working. Now we have one winding of the relay Ⓓ to Ⓤ included in the line circuit, and currents sent through it would, as before, reproduce our marks. A little consideration will, however, enable us to see that we can arrange to send through the winding U to D a current of the same strength as that in Ⓓ to , so that the relay armature will be unaffected. To do this we must connect the bridge of the key to D by a suitable resistance—that is, a resistance equal to that of the line, the distant apparatus, and our own galvanometer.

The Artificial Circuit. The circuit is now as shown in **46**. The part between U, D and the key may be called the *compensation circuit* or *artificial circuit*, and we see that our signals to the distant station pass through our own relay, but leave it entirely unaffected. Now we extend our considerations to both stations, arranging them similarly. On examination we find, first, that each station can signal to the other one without affecting his own apparatus. Secondly, we must consider what changes take place when, the key at A being already held down, that at B is also depressed. For this purpose we take another diagram [**47**], omitting everything except relays and batteries.

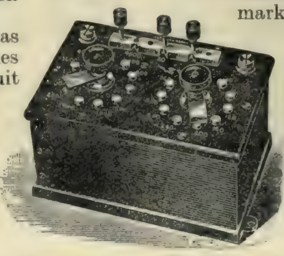
The circuits may be shown as three rectangles, X, Y and Z; and since X was made equal in resistance to Y, and Z was also made equal to Y, all three are of equal resistance. The current from battery A divides equally between X and Y, as shown by the single-headed arrows. Similarly, the current from B, which is of the same strength as A, divides equally between Y and Z, as indicated by double-headed arrows. As a result of the joint action of A and B, the current in the line circuit Y is double that in either of the compensation circuits X or Z. As a consequence the Ⓤ to Ⓓ winding of each relay is traversed by current double the value of that in the compensation circuits, so that both "mark." Each station can therefore signal through his own relay without affecting it, and



DUPLEX WORKING

45-48. Evolution of the Duplex from the Simplex **49.** Single-current sounder circuit with relay and switch for Duplex or Simplex working **50.** Connections of D pattern rheostat

can energise the distant relay whether the distant station battery is in or out of circuit. To facilitate adjustment, the galvanometers are also differentially wound, and the interpretation of their deflections has been explained in the practical section.



51. RHEOSTAT—D PATTERN

Battery Resistance. It has been stated that when both batteries are introduced into the line circuit the current is doubled. In order that this may be quite true, the doubling of the electromotive force must take place without any alteration of the total line resistance. The batteries, however, may have considerable resistance, so recourse is had to the expedient of introducing resistance coils, which take their place in the circuit alternatively with the battery. A complete skeleton diagram is given in **48**.

Duplex and Simplex Switch. On many circuits, especially provincial, it is necessary to work duplex only during the busy hours. To economise battery power a switch is provided by means of which the connections can be altered as required.

Fig. **49** is a diagram of the arrangement, and shows also the usual positions of the various parts on the instrument table. To add to his memory stock the student should take the switch terminals as times on a clock, beginning at 8 a.m., thus:

8 o'clock *split* of relay
10 ,, *three*
12 ,, *two*
2 ,, *rheostat*
4 ,, *one*
6 ,, *zinc* of battery

The italicised words can easily be strung together and retained as a mnemonic.

Rheostats. Variable resistance under this name are always used for the artificial circuits. They are made up of resistance coils [see page 789], connected so as to allow of any required resistance within certain limits being introduced into the circuit. The latest pattern, known as the D Rheostat, is shown diagrammatically at **50**, while **51** shows its external appearance.

Double-current Duplex. To alter a circuit from single-current to double-current duplex, it is necessary only to introduce a double-current key and to remove the single-current key and the battery resistance block. We proceed, therefore, in the direction of simplification, and all new duplex circuits in the Post Office administration are made double-current.

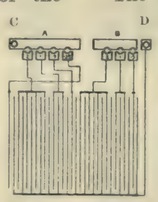
Long Circuits. For long circuits, however, it is necessary to modify the artificial circuit. When the line exceeds 100 miles, the difference between the capacity of the long and comparatively thick line wire and the negligible capacity of the few coils of small wire in the artificial circuit becomes sufficiently marked to interfere with the signals. Artificial capacity is therefore introduced in the shape of condensers.

A *condenser* is a development of the Leyden jar. For telegraphic purposes it is made by arranging a large number of layers of tinfoil and paraffined paper. Odd-numbered tinfoils are then connected together to form one surface, and even-numbered tinfoils to form an opposing surface.

It was pointed out on page 5178 that the capacity of lines varied as their surface, and inversely as their distance from the earth.

In the condenser artificial circuit, one metallic surface represents the line and the other represents the earth, and by reducing the distance between the surfaces to the smallest practical limits, the necessary amount of surface to provide a given capacity is surprisingly small.

The capacity of an ordinary aerial wire is about ·015 microfarads per mile.

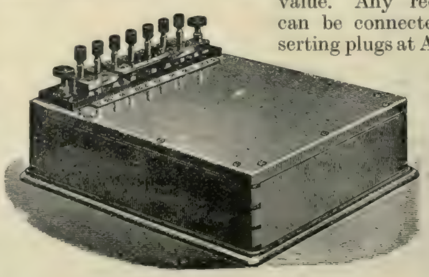


52. CONDENSER CONNECTIONS

Two microfarad condensers are made, having dimensions 7½ in. by 4½ in. by ½ in., so that in this small compass we have capacity representing 133 miles of line. For use in the artificial circuit, the condenser must be adjustable.

The Condenser. Figure **52** shows the internal arrangement of a 7¼ microfarad condenser, and **53** its exterior. C and D [**52**] are the terminals. The parallel lines represent layers of tinfoil, and the intervening spaces layers of dielectric.

One surface of each section is connected to D, the remaining surfaces being each connected to a brass segment marked with the appropriate value. Any required number of these can be connected to terminal C by inserting plugs at A or B. It will be observed, however, that there is a break between A and B. This is for the purpose of allowing what is called a *retardation coil* to be inserted.

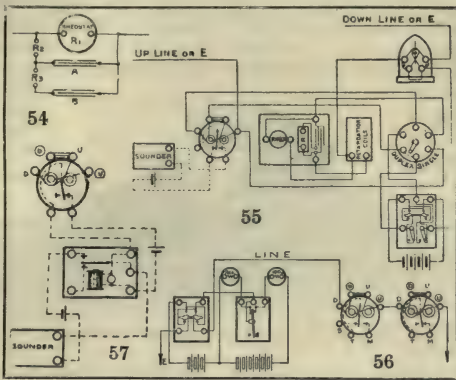


53. CONDENSER—7¼ MICROFARAD

The need for this will be seen if we consider the simultaneous charging of a long line, and the corresponding artificial circuit. The resistance of the line limits the maximum value of the charging current, and so lengthens the time necessary for the charge to reach its maximum.

Consider **54**, which represents the artificial circuit. R is the rheostat, and R2 and R3 are retardation coils. The section A of the condenser is charged through the resistance R1, while section B is charged through both R1 and R2. A therefore

corresponds to the near portion of the line circuit, and B to the more distant portion. Now if R2 and R3 were not present to slow down the rate of charging the condensers during the first instant of the charging process, the current to charge the artificial circuit would greatly exceed the current charging the line circuit, and would therefore affect the relay in the way we wish to avoid.



54. Arrangement of artificial circuit 55. Connections of double-current duplex. 56. Principle of Diplex system 57. Quadruplex—B side—uprighting sounder

Figure **55** is a diagram of the complete connections of a double current duplex. The student who has memorised the preceding examples will not find this difficult. In the mnemonic system, the right-front terminal of the key becomes No. 4, the rear-middle terminal No. 3, and the left-front may be called 0. The switch terminals will now read, "split, 3, 2, rheostat, 1, 0."

Quadruplex Working. The success of the duplex system led to further efforts to enhance the traffic capacity of a single wire, and although it had been suggested by others at an earlier date, it was Edison who first produced a practical system, in 1874. The main advance upon previous knowledge consisted in devising the diplex system, which enables two messages to be sent simultaneously in one direction.

Diplex Working. This is accomplished by providing, at the receiving end, two relays, one polarised and one non-polarised, connected in series to the line, while at the sending end there are two keys connected in series. One of them is a reversing key, similar in principle to the double-current key, while the other is an increment key.

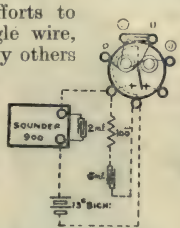
It will be kept in mind that a polarised relay is affected by the direction of the current. The non-polarised relay is affected by currents of sufficient strength, irrespective of direction, but it is in this case specially arranged so that it requires a current three times as great as that used normally for working the polarised relay. Figure **56** illustrates the principle.

The relay A is worked by the key A, exactly as in ordinary double-current working. Only one-third of the available battery power is being used, and the non-polarised relay B is unaffected. Immediately the key B is depressed, the strength of the current is trebled, and relay B is energised. The increase of current causes, of course, no inconvenience to the A set, as the *direction* of the current is still controlled by the A key.

Now if we imagine this arrangement modified for duplex working by using differential relays and an artificial circuit, we at once jump to the conception of the quadruplex system.

Diplex Difficulties. Such difficulties as are experienced in quadruplex working are connected with the diplex principle, so it will be well to dispose of them first.

So far it has been tacitly assumed that under all circumstances a current, either strong or weak, is flowing in the line. Consequently key B must be arranged so that it makes contact with the larger battery before breaking with the smaller. For the smallest practicable space of time the two ends of the larger section of the battery are connected by the increment key.

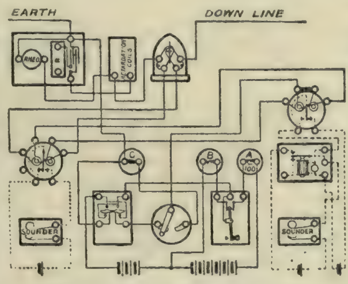


58. QUADRUPLEX CONDENSER—B SIDE

Spark Coil. To prevent the sparking which would ensue owing to the heavy current produced under such circumstances, a spark coil of 100 ohms resistance is inserted between the positive pole of the battery and the increment key. This removes any possibility of trouble from the variation in the strength of the current.

When the B key is properly adjusted, the A signals are good. We have still to consider how the working of A key affects the B signals.

As the A key reverses the direction of the current, it is evident that for an instant we have zero current, and if this occurs in the middle of a signal on the B instruments there is a tendency to splitting which has to be specially dealt with.



59. QUADRUPLEX UP-OFFICE CONNECTIONS

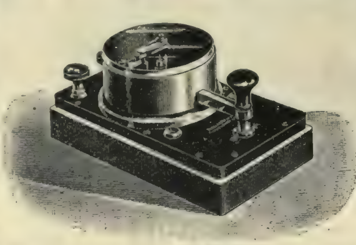
Uprighting Sounder. A very ingenious method for overcoming this difficulty was devised by Mr. Gerritt Smith, and is illustrated in **57**, in which the non-polarised relay, the uprighting sounder, and the reading (ordinary) sounder are shown.

It will be noticed that the relay is arranged so that it normally closes the circuit of the uprighting sounder, which in turn closes that of the reading sounder. In the ordinary case of relay and sounder, considered at page 5067, the sounder is not actuated until the relay tongue travels over to the marking stop. In this case, however,

we see that immediately the relay tongue *leaves* the right-hand stop the reading sounder is affected.

The important fact, however, is that under the influence of a signal current the tongue lies on the left stop. If any break in that signal occurs, *unless* it is so long as to allow the tongue to travel back to the right-hand side, *no* break in the signal on the reading sounder occurs. In practice, good working is easily attained.

Condenser B Side. Recently, however, it has been found possible to dispense with the uprighting sounder, and its battery, by taking advantage of the use of a condenser [58].



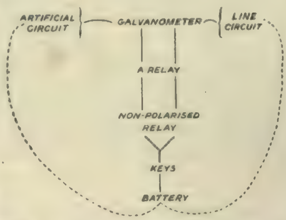
60. QUADRUPLEX INCREMENT, OR B KEY

The reading sounder has coils of 1,000 ohms resistance shunted by a coil of 9,000 ohms (joint resistance 900 ohms). Its terminals are connected to a 2-microfarad condenser. A 100-ohm resistance coil and a half-microfarad condenser are joined across the relay contact terminals to prevent sparking. It will be seen that in this device the capacity effects which in the line caused trouble are used to good purpose. The sounder can now be worked directly from the relay, and any small breaks in the signals are bridged over by the discharge from the condenser.

61. NON-POLARISED RELAY C

The A key is similar to that shown in 12, page 4607, but it has no "send and receive" switch, and consequently the middle-rear terminal provided in a double-current key is not needed here. Figure 60 illustrates the B or increment key. The A side relay is of the Post Office standard form already described on page 5067. On the B side a larger instrument, known as a non-polarised relay C, is used, as shown in 61. The armatures are placed obliquely between the pole-pieces, and currents in either direction tend to attract them against the tension of the spiral spring. Each armature is divided into two sections, which are brazed together. This magnetic separation tends to rapidity of action. Differential winding is employed, and the terminals are marked in the same manner as the Post Office standard relay.

Connections. Figure 59 is a diagram of a quadruplex up-station, showing all the "connections," as it is usual to call them. The student who has given some reflection to the arrangement of the duplex will quickly see the system followed in arranging the "quad." He will see that the current divides at the non-polarised relay, and follows in succession through the A relay and the galvanometer. The arrangement can, in fact, be symbolised in the manner shown in 62.



62. ARRANGEMENT OF MAKING UP QUADRUPLEX STATION

The two-way switch between the keys is the line and earth switch referred to in the last section as being used during the balancing process. When turned to the right it cuts off the battery to facilitate adjustment at the distant station. At the same time it substitutes the resistance coil shown connected to its right terminal. Its value is made equal to the resistance of the battery and spark coil combined.

Current Values. The current strengths required for quadruplex working are, for the A side, 15 milliamperes, and for the B side 45 milliamperes. This gives a ratio of three to one between the B and A currents, and practice has shown this to be the most suitable value. Bichromate cells are used for the main and local batteries. For the uprighting sounder and the relaying sounder three cells each are used. When the uprighting sounder is substituted by the condenser method of arranging the B side a battery of 13 bichromate cells is used for the local circuit.

Although the quadruplex came to us from America, much of its present good working is due to subsequent English improvements, and there are now over 500 sets at work in the United Kingdom.

Manual versus Automatic Systems. All of the systems so far dealt with have been of the manual order—limited as to speed by the expertness with which the operator could, letter by letter, form the signals. We shall now proceed to discuss various systems in which automatic methods of making the signals at high speed are employed. It should, however, be noted that in the manual system the three operations of forming the signals, transmitting the currents, and transcribing the signals are performed simultaneously, whereas, in the automatic systems they must be performed seriatim. These facts have exercised a strong influence in favour of manual systems and continue to do so to such an extent that in this country the manual sets outnumber the automatic, so far as the Post Office is concerned, by 25,492 to 585.

It can easily be seen that where towns separated by, say, 500 miles are concerned, the inducement to save the expense of additional lines by using automatic methods is considerable, but even the longest circuits in the United Kingdom are worked manually.

Continued

THE LIFE NOT WORTH LIVING

Continued from page 5100

The Degradation of the Bee-hive Conception of Society. Is an Ant-hill Worth While? The Supreme End of Society is the Development of Personality

By Dr. C. W. SALEEBY

WE are now quite ready to accept the doctrine of Carlyle: "Man is created to fight; he is perhaps best of all definable as a born soldier; his life 'a battle and a march,' under the right general. It is forever indispensable for a man to fight; now with necessity, with barrenness, scarcity, with puddles, bogs, tangled forests, unkempt cotton; now also with the hallucinations of his poor fellow-men." We have seen how, even in the spiritual type of society which we have imagined, this born soldier, man, will have to fight with and ultimately command Nature ("only by obeying her"), and, still more, must ever fight against the weaknesses of his own nature. There will be room for the soldierly qualities until the end of time.

The Spiritual Type of Society. But now we must consider from another point of view this spiritual type of society, in which military and even industrial warfare will have ceased, and must endeavour to express its characters in strictly sociological terms—that is to say, in terms of the relation between individuals and society. Here we can certainly find no better guide than Professor Höffding. In a recent lecture to the Sociological Society in London, the great thinker of Copenhagen thus expresses the sociological ideal ("Sociological Papers," 1905. Macmillan):

"If the single individual in developing itself in its own peculiar way gives the best possible contribution to the whole life of society, and if, on the other hand, society is organised in such a manner that a free and full development is possible for all individuals, then we are approaching to the ethical ideal."

In the same great thinker's "Philosophy of Religion," which is surely the greatest work of the greatest thinker now alive, we find the same ideal well expressed (English Translation, Macmillan, page 359):

"Self-assertion is no longer exhibited as the opposite of love. For magnanimity possesses strength enough to support not only the individual's own life, but also the life of other men. And the highest virtue is justice, in which both self-surrender and self-assertion are included. *The ideal is a kingdom of personalities, in which each individual unfolds his personality in such a manner that in this very act he helps others to unfold their own.* This conception offers free scope to all those ethical elements fostered by Christianity which are of lasting value." The italics are ours.

The Four Kinds of War. At present, observe, even though we hear less of military warfare, we hear only too much of internecine warfare within the society itself. That famous old Dutch writer, Grotius (1583-1645) distinguished four kinds of war—the individual against the individual, society against society, society against the individual, and the individual against society. It is the two latter kinds of which we hear so much to-day, and we see that in the ideal state as pictured by Höffding these have vanished. The ideal is only the sociological expression of Spencer's great discussion of the ultimate reconciliation of egoism and altruism.

We must go back to classical English, however, for the finest expression of our ideal, which Spencer and his followers have detailed in these scientific times. Altering its application, we may remind ourselves of the fine phrase "whose service is perfect freedom." In the ideal state of society we shall see no more of any of the four kinds of war which Grotius distinguished. Each man's service of his fellows will be compatible with his own perfect freedom. In a word, the social ideal is anarchy—the higher anarchy. To this we may hope to return.

The First Fact about Society. We have now discussed war as fully as our space will permit. We have seen in it a means which has been employed in the organisation and development of society. Even the wars of religion, perhaps, may show to the seeing eye the "soul of good in things evil." We have refuted the popular doctrine that men decay unless they fight, and unless they fight with fist or gun; but have admitted that man must always struggle or strive, and we have endeavoured to point to the direction which the evolution of human strife is taking. Now, having considered the fundamental social institution—marriage and the family—and this great factor of struggle between and within societies, we must turn our attention to the larger outlines of the constitution of society, and though we may begin with far-away biology, we shall find ourselves, before long, grappling with the most urgent political question of the hour.

The fundamental fact of sociology, which constitutes the *differentia* of our science, is that society is not an aggregate but an organism—not a heap of bricks, but those bricks built up into a building. Thus, the problems of society are not simply the problems of the individual multiplied by the number of individuals within the society. This is the first fact which we have to study in regard to the constitution of society. It is fundamental because it is true of all societies, and is not affected by forms of Government. It is true of a democracy or a monarchy, of a communistic or an individualistic state; and this study of society as an organism yields us facts and principles of universal application by which we may be enabled to judge the relative

worth of such varying forms of external constitution. Similarly, for instance, the biologist has to study such markedly contrasted organisms as an oak and a horse; but though the external constitution of the two is so different the fundamental fact of the two is the same—the interdependence of the unit and the whole.

St. Paul as a Sociologist. The idea of comparing society to a living creature is very old and very celebrated; and the significance of the comparison has been found to grow with the growth of any sound sociology. If we go back even to Socrates, the immortal founder of the supreme science of ethics, we find his pupil Plato, to whom we owe all that we know of the teaching of Socrates, conceiving of society as an organism. A few centuries later, we find St. Paul, who was a philosophical genius of the highest order, repeatedly employing the image in question. Through the whole of his epistles we find him comparing the early Christian Church to a living body, and using the comparison as the basis of many valuable arguments. The present writer thinks that sociologists have not adequately recognised the place of St. Paul in the history of this subject. We may quote from the twelfth chapter of the Epistle to the Romans a typical instance of St. Paul's employment of this figure: "For as we have many members in one body, and all members have not the same office: so we, being many, are one body in Christ, and every one members one of another."

From the same age and from Rome itself, we may quote the classical fable of the rebellion of the rest of the body against the privileges of the stomach: "There was a time when all the body's members rebelled against the belly." Shakespeare uses this with great skill in "Coriolanus," Act i. Scene 1, where he makes Menenius employ this argument against the discontented citizens, saying, "The senators of Rome are this good belly and you the mutinous members," and contemptuously calling one of the complainants who was prominent but contemptible, "the great toe of this assembly."

In more recent times we have that remarkable genius, Hobbes, who wrote the great book "The Leviathan," in which, as the title suggests, he compares the State to a huge animal.

The Social Organism. But it is not until the time of Herbert Spencer that we find this ideal worked out with adequate knowledge. For one thing, his predecessors had not known enough about the structure of individual organisms to enable them to make anything but merely general or poetic comparisons. When Spencer came to the subject, certain great facts had lately been discovered, and he used them like the consummate genius that he was. The cell theory had lately been advanced. Fortunately, there is no need for us to discuss its meaning here, since the reader has been well prepared by other courses. In 1850, then, in his first book, "Social Statics," and notably in his great essay on "The Social Organism," published in 1860, and now to be found in the first volume of his republished essays, Spencer introduced that phrase "the social organism"—conveniently contrasted with the individual organism—which, like so many of his ideas and phrases, is now employed every day as an instrument of argument and of thought.

A society of electrons constitutes an atom, as we have lately been studying, a society of atoms a molecule, a society of molecules a living cell, a society of cells an individual organism, and a society of individuals a social organism.

A Great Man's Great Error. As we pass upwards in this scale, and reach the three living units which constitute its last three terms, we find illustrated more and more abundantly that great principle which Milne-Edwards, the French student, called the "physiological division of labour"—the differentiation of function and of structure, so that the part becomes not merely or not at all an end in itself, but merely a servant of the whole. We have seen how completely this was recognised by St. Paul, and in the Roman fable, as true of the individual organism and of the social organism. We now know that it is absolutely true of the cells—with nucleus, centrosome, and so on—which constitute the units of all individual organisms; and if we recognise the family as the unit of all higher societies, we can recognise the physiological division of labour in it also, only it is now more than physiological and has become sociological: the mother has one function and the father another.

Only very briefly here need we consider the working out of the last and most important part of our analogy—the analogy expressed by Hobbes, though with many fundamental errors, when he speaks of "the great leviathan called a Commonwealth or State, in Latin *civitas*, which is but an artificial man." The last word in the whole world that is true here is the word artificial. Both Plato and Hobbes fell into this fundamental error—that societies are artificial structures "to be consciously put together by men, just as a watch might be."

Societies are Natural and Inevitable. As Spencer points out, they thought that "what is in its nature an organism is in its history a machine!" We see exactly the immeasurable difference between Spencer's conception—the conception of the author of the idea of *natural* evolution—and that of his predecessors when we discover that Hobbes "even goes so far as to compare the supposed social contract, from which a society suddenly originates, to the creation of a man by the Divine fiat." We now know that man was not so created—nor any societies. We utterly reject the hypothesis of manufacture in both cases, and we believe it to be true of man as well as societies that "constitutions are not made but grow." Furthermore, the growth of societies is as inevitable a consequence of the laws of Nature—which, as we must never forget, include the laws of human nature—as is the growth of individual organisms. In Spencer's words: "While each citizen has been pursuing his individual welfare, and none taking thought

about division of labour, or conscious of the need of it, division of labour has yet been ever becoming more complete. . . By steps so small that year after year the industrial arrangements have seemed just what they were before—by changes as insensible as those through which a seed passes into a tree—society has become the complex body of mutually-dependent workers which we now see. And this economic organisation, mark, is the all-essential organisation. Through the combination thus spontaneously evolved, every citizen is supplied with daily necessaries; while he yields some product or aid to others. That we are severally alive to-day, we owe to the regular working of this combination during the past week; and could it be suddenly abolished, multitudes would be dead before another week ended."

Individuals and Societies. We need not now concern ourselves with the comparisons of Hobbes, some of which are very good and some very bad. Nothing could be worse than his comparison of the sovereignty to "an artificial soul as giving life and motion to the whole body." On the other hand, this is good: "Councillors, by whom all things needful for it to know are suggested unto it, are the memory. . . . Concord, health; sedition, sickness; and civil war, death."

In the light of modern knowledge we may venture to quote our own comparisons: "The governing mechanism of a society corresponding to the nervous system; the manufacturers to the glands, permanent officials to the bones, traders to the circulatory apparatus, soldiers and scavengers to the white blood cells—and so on."

But now we come to that which gives the whole analogy its value—that for which we are lastingly indebted to Spencer. His summary of the *points of resemblance* between the individual organism and the social organism is well worthy of quotation, especially as it can only be obtained in a very expensive volume. We give it here; and then we would ask the reader, before proceeding any further, to see whether he cannot anticipate for himself the equally important question of the *points of difference*.

Herbert Spencer's Comparisons. The points of similarity between societies and individual organisms are these:

1. "That, commencing as small aggregations, they insensibly augment in mass, some of them eventually reaching ten thousand times what they originally were.

2. "That, while at first so simple in structure as to be considered structureless, they assume in the course of their growth a continually increasing complexity of structure.

3. "That, though in their early, undeveloped states there exists in them scarcely any mutual dependence of parts, their parts gradually acquire a mutual dependence which becomes at last so great that the activity and life of each part is made possible only by the activity and life of the rest.

4. "That the life of a society is independent of, and far more prolonged than, the lives of any of its component units, who are severally born, grow, work, reproduce, and die, while the body-politic composed of them survives generation after generation, increasing in mass, in completeness of structure, and in functional activity."

The Difference between Individuals and Societies. It is to be hoped that the reader has anticipated what we are about to say. At a certain point the analogy between the individual organism and the social organism breaks down utterly, and the value of the analogy lies in its demonstration of the point of difference. There are other points of difference discussed by Spencer, but they are relatively trivial; there is only one which is vital. We recognise it directly we ask ourselves the end or object in either case. The object of the individual organism is *its own life*. Let the reader take his own case. All the cells and parts of his body have no meaning, purpose, or value as ends in themselves; they are means merely to one end—*his* life. He cares nothing for any part of his body except as it ministers to his well-being. "In washing my hands I write an indistinguished *finis* below the history of millions of my cutaneous cells; yet I never waste another thought on them. *I* prefer my hands clean, and there's an end on't." We may turn again to the Bible for the supreme expression of this truth—the truth that no part of the body is of any worth or meaning except as it serves the self: "If thy hand or foot offend thee, cut them off and cast them from thee. . . And if thine eye offend thee, pluck it out and cast it from thee." The hand, the foot, the eye have no claims on their own account, and may be destroyed—nay, must be destroyed—if they do not serve their owner.

Society has no Self. And here is where the analogy breaks down. We know what we mean by the welfare of the self, but what do we mean by the welfare of the State or body-politic? Society or the State has no *Self*. Says Spencer: "It is well that the lives of all parts of an animal should be merged in the life of the whole, because the whole has a corporate consciousness capable of happiness or misery. But it is not so with a society, since its living units do not and cannot lose individual consciousness, and since the community as a whole has no corporate consciousness. This is an everlasting reason why the welfares of citizens cannot rightly be sacrificed to some supposed benefit of the State, and why, on the other hand, the State is to be maintained solely for the benefit of citizens. The corporate life must here be subservient to the lives of the parts instead of the lives of the parts being subservient to the corporate life.

This conclusion of Spencer's is absolutely in accord with the fine expression of the social ideal which we lately quoted from Professor Höffding. That ideal fully recognises that the welfare of the State, unless it mean the welfare of its individual citizens, is nothing. "Only in the consciousness of individuals can the value of life be experienced." Life is personal or nothing—human

life, that is to say. A few chapters ago we alluded to a contrast which will serve us here.

Man and the Beehive. In our brief attempt to cover an infinite subject we have been able merely to allude to that department of it which we may call Comparative Sociology. This study is only in its infancy, even though a good deal of attention has lately been paid to the societies of the social insects. Yet even already, as it seems to the present writer, we may learn a lesson from the beehive.

In this case the evolution of society has taken a course of its own. Life is no longer personal life, but communal life. In the beehive the individual unit is of no importance as an end in itself, and the same is true in the ant-hill. Neither of these institutions will give anything for our doctrine that "only in the consciousness of individuals can the value of life be experienced." The beehive does not care a straw for the consciousness of individuals. The individual worker or drone is of just the same importance to it as a cell of your skin is to you. When the cell has done its work you wash it off and cast it to the drains. Similarly, when the individual of the beehive has outlived its usefulness, it is quietly made away with, just as savage tribes make away with their old people. The beehive shows us the analogy between the individual and the social organism carried out to the uttermost. The welfare of the individual is naught here as compared with the welfare of the State. The analogy that breaks down so signally in the case of human society holds here all along the line, and Spencer's "everlasting reason" is null and void.

Beyond a doubt, the consequence of the subordination of the individual to the society achieves the end for which it is compassed, and there can be little doubt that the same would be true in human society. In coming years, it seems, we shall be making the experiment, as if the whole of the history of life, including the life of the bee, did not already include a record of this experiment.

Life at the Level of the Ant-heap. In general, life obtains what it strives for. In this case the object is the security and stability of the society. To this object the individual is ruthlessly sacrificed, and this object is attained. The ant-hill and the beehive are typical instances of social stability and efficiency. They can hold their own against other societies, and they have persisted for millions and millions of years. Bees and ants, be it remembered, are not even vertebrates; they are mere *Insecta*, and had their origin before even the earliest fishes, and they thrive to-day.

But what is it all worth? The whole existence of such a society, where the individual is nothing, is itself nothing. What is lost if the ant-heap be destroyed? Simply an ant-heap—simply a living machine which had sacrificed everything else, everything that makes life worth living, to the mere maintenance of a life that was not worth living. No more horrible prospect can be conceived for human society than its degradation to the level of the ant-heap or the beehive—a level which, despite its beauty of organisation and its success, we will yet call degraded. Estimate it in terms of worth, estimate it in terms of ethics, in terms of consciousness, and it is naught. It is merely an animated machine which has sacrificed to life all that makes life worth living.

The Worth of the Individual. Yet, again, what do we find in the society which has completely carried out the analogy between the individual and the social organisms, in which the individual is not an end in itself any more than the cell of the reader's epidermis is an end in itself? If such a state of things were to lead to something higher, then, though we might deplore it as an end, we should welcome it as a means to the higher end. What, then, is the condition of such a society in relation to progress? The answer is that the constitution of such a society involves the utter destruction of all the factors of progress. In such a society there is no place for individuality, character, or genius. It will burn or hang or poison its genius as surely as the Athenians poisoned Socrates, and it will never advance an inch. Such a society lives only in name; it is a clever and efficient machine, but it is as essentially and spiritually dead as the engine of a motor-car. Men and women, living personalities such as ourselves, can pronounce no other verdict upon it. Life is either a matter of personality or a stage towards the development of personality —or else it is mere "putrefaction of the dust":

"A tale
Told by an idiot, full of sound and fury,
Signifying nothing."

Society is More Than an Efficient Machine. The society, then, in which the welfare of the individual is no end in itself, in which individuality and personality are criminal nuisances, such a society may be as efficient as a beehive and as persistent as the insects; but it has said to itself, "Thus far and no further," and it is as dead as any steam-engine. Worse, indeed, is its state, for there is no spectacle so lamentable as that of life, whether insect life or human life, which has thrown away the substance for the shadow —the society wherein men and women toil for that which is not bread merely in order that the social organism may be an efficient machine, military or industrial.

It now remains for us to ask ourselves the conditions under which we may hope to realise the ideal expressed by Höffding. The beehive and the ant-heap show us the perfect fulfilment of the first half of that ideal. "The single individual, in developing itself in its own peculiar way [cf. the unsexed worker-bee], gives the best possible contribution to the whole life of society." But the other half of the ideal, the consecration of the "whole life of society" to the worthy, full and free development of each individual—this has been made for ever impossible.

How is it to be made possible for us?

Continued

A MARVELLOUS MACHINE

The Linotype and Monotype Machines. How they Cast and Set Up Type. The Furniture of the Composing-room

Group 19
PRINTING
3

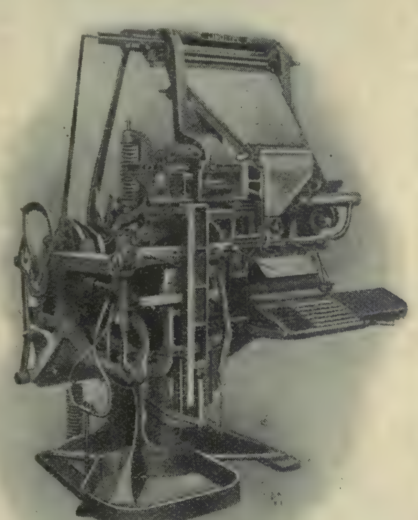
Continued from page 5159

By W. S. MURPHY

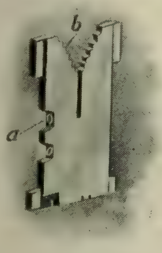
DURING the latter half of the nineteenth century, when machinery was revolutionising trades formerly considered impregnable to the cunning of the inventor, the compositor, secure in the belief that type-setting required a combination of hand and eye, foresight and judgment only possible to the human brain, viewed the efforts of mechanics to invade his province with amused indifference. Invent a machine that can think, and you will make a mechanical compositor, said the printing trade to the inventor, little thinking that the challenge would be accepted.

The Linotype. In the year 1886 news came from America that the problem of mechanical type-setting had been solved, and, in 1889, a Linotype machine was brought over to this country and set to work. Though not the perfected machine now operating in newspaper and book offices all over the country this early specimen demonstrated that the main problems had been solved, and that the mechanical compositor was an accomplished fact.

Like nearly every mechanical invention of importance, the Linotype composing machine [10] is a growth, a combination, and an adaptation of devices previously existing. At the front of the machine is a keyboard, borrowed from the piano-keys, applied early by type-setting inventors and brought into practical use by the typewriter, and at the side you see what is actually a type-founding machine, while in the middle are the matrices and matrix channels variously developed [14]. The makers of the Linotype thus describe its evolution: "First in order were matrix machines, designed to punch letters one after another in lead or papier-maché, and thus produce a page or column matrix, from which to cast a stereotype at a subsequent operation. Next came machines in which a number of dies were composed in a line, the line justified, and the entire line then impressed at one operation in some matrix material. During the development of the matrix machine the revolutionary step was taken of casting from the machine-made matrices independent type lines, or slugs, now known the world over as 'Linotype.' Last, the typewriter keyboard was applied, and the machine completed."



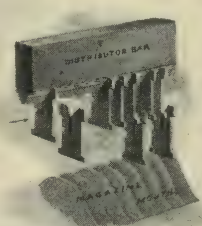
10. LINOTYPE MACHINE



11. LINOTYPE MATRIX
a. Letter-die b. Grooves

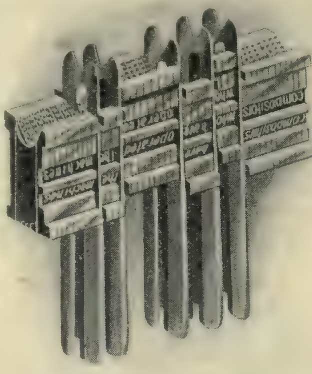
What the Machine does. The mind of the hand compositor is occupied with reading the copy, selecting the letters, placing them in the setting-stick, spacing out lines, and justifying. Now let us see what this intelligent machine does. The Linotype is not yet able to read copy or spell words; but it selects the matrices, places them in line, spaces out, and justifies correctly.

Complex as the Linotype machine is, it is not difficult to understand, because every part acts directly. The *keyboard*, D [14], has 90 type keys and a space key, J. The operator has set his copy in the holder, and taken a phrase into his mind. He taps letter after letter on the keyboard till a word is spelt out, then touches the space key, and on to the letters again. At every click of the keys there is the clink and slide of brass, and yellow metal flashes along the endless belt, F, running at a slant above the keyboard. The belt extends under a series of vertical channels, E, short at the right, and lengthening to the left, and above rests a broad, flat box, almost triangular in shape. This is the matrix magazine, A. Within the box lie long grooves containing winged plates of brass;



12. DISTRIBUTION OF MATRICES

these are the matrices. In the vertical edge of the little plate a die of a letter is deeply cut [11*a*]; the triangular cut in the head is grooved [11*b*], and the proportions of the grooves in every matrix are different. The motion of the key rods, C, releases B, the check escapement of the matrices, letting the proper matrix drop down the channel below, and on to the flying belt, which bears it to the assembling block, G, at the side. The space wedges, I, come from a box, H, through a channel of their own, but in obedience to a similar call, and slip between the words.



13. LINE OF MATRICES
Showing method of spacing

The Moulding of the Type. Though scarcely full, the line will not hold another word or syllable. But the operator does not pause to justify; he merely presses down a handle on the right of the keyboard, and begins another line, and the neglected line moves on to the face of the mould-wheel, K, where the wedge-like spaces are driven up to fill out the line [13]. The mould-wheel carries a mould in which a slot is cut, the exact breadth and depth of the type, and on to this the matrices clamp, forming a complete mould. Behind the wheel is the metal-pot, M, containing type metal, kept in a liquid state by a gas burner, with an automatic plunger pump. When the mould-wheel has got into position, the metal pot comes forward and the spring plunger jerks a jet of metal into the mould, casting the line of type. This done, the mould-wheel turns round and sets the line on end, level with the trimming knives. From behind comes a pushing blade that drives out the line into a little galley in front of the machine.

14. DIAGRAMMATIC VIEW OF LINOTYPE MACHINE

While all this has been going on our operator has been setting another line, and before it is complete, the mould-wheel is waiting to begin another round. The older engineers could not trust their contrivances to do more than purely mechanical work under constant supervision, but here one act brings on another, and even impetus is taken advantage of with cunning skill. Take, for example, that slanted belt and the matrix channels lengthening from right to left. The assembling block is at the left side, and if not otherwise guarded against, the matrices on the right side of the machine would have to travel more than double the distance of those on the left. Note, however, that the channels on the left are nearly as long as the breadth of the magazine, while those at the right side are shorter. The comparative brevity of the channel, and the speed of the flying carrier belt, enables the most distant matrix to arrive at the assembling block in the same time as the nearest. Say capital X is at the far side, and small "e" is just above the assembling block. X has to drop down its short channel and fly along the belt, while "e" has only to drop down its long channel; but no matter how quickly you strike "e" after X, the X will get there first.

Distributing by Machinery. When a line is *cast*, the matrices must be distributed, or cleared out of the way, and here again the automaton acts without direction. The used matrices are lifted up to the top of the machine by means of an elevator, R, and given into the grip of a distributing bar, T, fixed over the mouths of the matrix channels [12] of the magazine. Along this bar the matrices are moved by means of three endless screws, and, the bar being cut into wards corresponding to the grooves in each matrix, each drops into its proper channel. The arrows and dotted lines in the diagram indicate the course followed by the matrices.

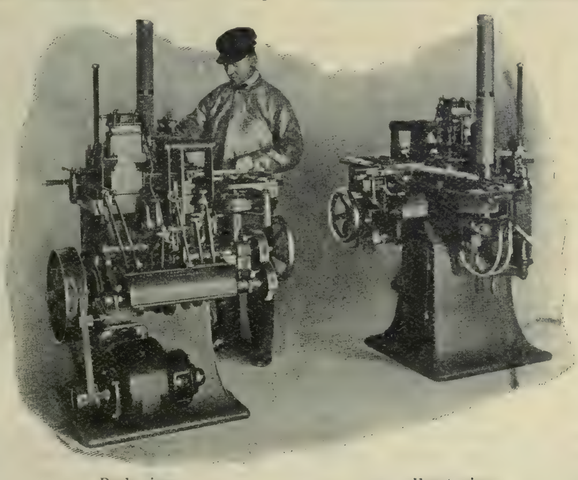
To get the most out of a machine so finely adjusted, the operator should not merely learn his keyboard, but should make himself acquainted with all its parts, so as to feel the least hitch and remedy it at once. He must also keep in mind that even the smallest correction involves the resetting of a line, and an "out" may call for setting a whole paragraph over again. The machine has great advantages and small disadvantages, and the latter can be minimised by

careful workmanship. An average Linotype operator is able to produce as much as five hand compositors, but an expert will easily double that speed. The illustrations **10-14** have been supplied by the Linotype and Machinery, Ltd.

The Monotype. The Monotype is another triumphant combination of modern mechanical ideas. The typewriter, the pneumatic tube, the telegraphic ribbon, the cone drum, the Jacquard weaving apparatus, and several other new ideas have been utilised by the inventor of the Monotype. Properly speaking, it is not one, but two machines, the one with the keyboard producing the record [**15**], and the other casting the type [**16**]. The keyboard is of vast extent, having no fewer than 257 keys, thirty being space regulators, 225 for letters, spaces, and signs, and the other two for justifying scale and reversing actions. At the back of the board is a ribbon of paper, rolling off one spool on to another, and, unseen below, rest 31 punches. A pneumatic pump drives air into the keybank at a pressure of 15 lb. to the square inch. These are the tools of our machine, and now see how they work.

15. MONOTYPE COMPOSING MACHINE

Punching the Ribbon. When a key is depressed, it releases the current of air, which drives one or two punches into the ribbon, as the case may be. Every key releases a different pneumatic combination of punches, making different patterns on the ribbon, translating the copy into a perforated record, similar to the telegraphic tape or the phonographic cylinder. The spacing and justifying arrangement is ingenious. When the line is set, or rather punched, to within four ems of the end, a bell rings, and as the operator puts in the last letter he can get into the line, he touches a green key that indicates two numbers on the justifying scale drum. Obediently he presses these, and the intelligent machine, having previously kept count of the number of spaces in the line, proceeds to make a record on the paper which will give exactly the proper addition in thickness to each space.



Back view Front view

16. MONOTYPE CASTING MACHINE

Casting and Moulding. The spool with the ribbon record is now taken to the casting machine, which looks very complex, but is in reality simplicity itself, the machine really being three put in one. First, there is the casting machine proper, with its pot of molten metal and forcing-pump and valve, set below the mould holder. Secondly, the die case ready to direct the matrices on to the mould as required. And thirdly, pneumatic apparatus that directs the setting of the die on the mould, under the direction of the perforated paper or ribbon record. Now we can follow the whole action. The perforated tape moves forward one marginal perforation under the air-pressure bar, releasing the air to propel the mechanism of the die-case, and placing the matrix [**17**] required into its proper position to the mould; the matrix-case [**18**] adjusts itself to the mould, to the top of which the matrix is clamped; the force-pump injects the molten metal and the type is cast; the matrix-case lifts itself from the mould, and the carrier bears the type into a channel, where the line builds itself up. At the end of the line the casting operation and type-pusher stops and the galley gate lifts to permit of the line being automatically pushed into its place on the galley.

Whilst one type is being delivered into the channel another is being cast in the mould, hence the rapidity of the whole operation.

So long as type-metal and perforated paper are supplied to the machine the production and composition of type continues unchecked. The illustrations **15-18** have been supplied by the Lanston Monotype Corporation, Ltd.

On the relative merits of these two thought-saving machines it is not our province to give an

opinion. The Linotype is probably the handier and better suited for newspaper work; the Monotype is the more mobile, and presents a larger range of letters at one time. Movable type has its advantages, but the solid line is more easily handled. Looking at them both, the wonder in our minds takes the form of the inquiry, What next? The transition from the monotype record to the phonographic record is very small. Will any genius make the bridge, and change spoken words into solid type?

17. MONOTYPE MATRIX
(Much enlarged)

A Look Round the Composing-room. It must not be understood that a composing-room is only a place for setting type, and wholly furnished with composing frames. Set at places convenient for the business, stand tall frames called racks, holding as many as thirty-five cases in them. These cases are filled with various kinds and sizes of type, some holding large sizes, some small type rarely used, and others fancy types of all sorts and sizes. We have mentioned the leads, the slips of metal which the hand compositor uses to make space between the lines of type; there is a rack containing nothing but cases of leads, ranged between slips of wood in sizes from four-ems up to sixty. When the compositor needs leads, he goes to this rack, draws out the case containing the size he wants, and lifts out a handful.

The Brass Rules. In many offices, there is another set of cases most important to the compositor. These are what they call the *brass-rule cases.* Here, in neat boxes, exactly fitted to the varying and graded lengths of the rules, lie the slips of brass that print the column lines, cross-lines and other sorts of lines, needed in tables, or matter that requires marks of separation between one part and another. One case holds the thin brasses—eight-to-pica, as they are named—and on the side the length of each is engraved, usually running from two-em up to 40. The next case holds thicker brass rules, six-to-pica. Another is full of what are called fancy brasses, thick and thin, long and short, waved, starred, double, triple, and variously designed, for ornament. Then, in all newspaper and most other offices, there are what they call column rules, generally two-to-pica, but graduated to a thin line on the face. To produce the heavy black lines in obituary notices the column rules are just turned bottoms upward.

The Furniture. Borders, fancy dashes, and other ornaments belong to the jobbing department, and we shall see them when that department is entered. But there are many things yet to be seen in the composing-room, necessary to all printers. The spaces between pages, blank pages in books, and large breaks in between one piece of type and another, are all filled in with what is called *furniture.* Furniture is made of wood and metal. Look at a case of metal furniture first. It is made up to pica both in length and thickness, and begins at four-em broad by one-em thick. Next are the two-em thick, and these seem like two pieces cast together; the three-em have holes in the middle, and the four-em are made hollow squares. This principle is followed in all sizes of metal furniture, for obvious reasons of economy and to render the weight of metal as light as possible. Excepting the smaller sizes, every breadth of furniture runs up to eight-ems thick, and a solid bar of lead 15 in. long by about 2 in. thick would be rather difficult to handle. Wood furniture is made of seasoned oak and supplied in lengths which the printer can cut up to suit himself, the thickness being graded in the same way as the metal furniture. Metal furniture is more liable to break in use, but is more rigid, and better suited for small spaces.

Galley and Forme Racks. Round the room there are numerous other racks and stands. This tall, narrow frame is a *galley rack,* and into it are slipped the galleys full of type awaiting making up into pages, author's corrections, or sometimes a dilatory compositor's correcting. Beside it stands the *galley press,* an iron stand like a long, narrow table, railed on both sides with a heavy iron roller covered with felt resting on the rails. The galley to be proofed is laid on the table, rolled with ink, covered with a slip of paper, and run over with the heavy roller, the result being a slip galley proof.

18. MONOTYPE MATRIX MOULD

Then there are *forme racks,* holding in vertical position sets of pages of type locked firmly in iron frames technically called *chases;* racks for keeping in good order the iron chase frames themselves; long tables covered with type, some of it tied up for keeping, some of it awaiting distribution; and, most conspicuous of all, the large, heavy tables, iron-topped, called *imposing stones,* the uses of which we describe at length on a later page.

Continued

A SHORT DICTIONARY OF TERMS USED IN PRINTING

ACCENTS—Accented letters.
Ads.—Advertisements.
Apron—Flap of paper pasted on matrix.
Ascending Letters Letters with heads extending above body, as b, d, f, h.

BACK MARGIN—Inner edge of page.
Bank—Bench for sheets of hand press.
Bastard Fount—Type with body out of proportion to face.
Bastard Title—Abbreviated title-page.
Beard—Space on body of type allowed for ascending and descending letters; also called shoulders.
Bearer — Type-high metal, used to modify impression.
Bed—Type-carriage.
Bevel—Sloped edge of stereotype plate.
Bill—A poster.
Bind—Obstruction of type in locking-up.
Blanket—Impression pad of wool, felt, or rubber.
Blocks—Mounted plates, or woodcuts.
Board—Flat piece of wood for holding type.
Bodkin—An awl used in correcting.
Body—Shank of a letter; page without headlines, folios, or footnotes; book, without preface, title-page, &c.
Bourgeois—Size of type (9 points).
Boxes—Divisions of type-case.
Brace—Sign of inclusion, coupling.
Brass Rules—Slips of brass used for printing lines.
Break—End of a paragraph.
Brevier—Size of type (8 points).
Brilliant—Size of type (3 points).

CAP.—Capital letter.
Case—Shallow wooden tray divided into compartments for holding loose type.
Cast—Moulded metal, type or plate.
Cast—Blackening of sheet at second impression by cylinder or tympan fouled by ink from first printing.
Casting-box—Iron box, forming, with the matrix, the mould of type or stereotype plate.
Cast-off—Calculating length of MS.
Catch-line—Words at head of galley denoting contents.
Chase—Iron frame in which type is locked.
Clicker—Workman who distributes copy and makes up pages or columns.
Clump—Type-high metal, put round pages to be stereotyped.
Coffin—Type-carriage of press or machine.
Copy—Manuscript.
Cuts—Woodcuts, or illustrations.
Cylinder—Horizontal roller on printing machine.

DESCENDING LETTERS—Letters with tails below the body, as g, p, q, y.
Dis.—Type ready for distributing back into case.
Dressing—Placing forme on machine, and preparing cylinder.

ELECTRO—Electrotype plate of page or picture.
Em-quad—Space the square of depth of type body
English—Size of type (14 points).
En-quad—Half of em.

FACE—The letter on the type.
Footstick—Half-wedge put at bottom of type in chase, for lock-up.
Fore-edge—Outer margin of page.
Forme—Type locked in chase; specially applied to groups of pages.
Frame—Wooden or iron structure holding type-cases, forming bench for cases in use.
Friar—A light mark on printed sheet.
Frisket — Paper-covered frame, with opening cut to size of type; folded on the tympan to protect the sheet.
Furniture—Metal or wooden blocks for spacing between pages.
Flong—Substance of stereotype matrix.

GALLEY—Tray for holding type when it is set.
Galley Press—Press for proofing type on galley.
Galley Proof—Slip printed from galley.
Gem—Size of type, (4 points).
Great Primer—Size of type (18 points).
Gripper—Bar set on cylinder to take on sheets.
Gutter—Space between pages in forme.

HAIR SPACE—Thinnest of spaces, eight to the em.
Hand Roller—Ink roller of hand press.
Hoe—A rotary printing machine.
Hot Plate—Steam-heated plate for drying stereo matrix.

IMPOSING STONE—Table on which set type is prepared for printing or stereotyping.
Imposing Schemes—Method of placing pages so that they will print in order.
Impression—Stamp of type on paper.
Impression Cylinder—Cylinder carrying and impressing the sheet on type.
Imprint—Name and address of printer.
Indent—Space shortening first line of paragraph.
Inferiors — Index figures or letters, smaller than type body, ranging with bottom of letters.
Inner Forme—Set of pages containing the second and second last pages of a sheet.
Italic—*Sloping type, like this.*
Inset—Supplementary matter.
Inverted Commas—Quotation marks.

JOB—Any work not a book or pamphlet.
Jobbing—Doing odd work; commercial printing; small jobs.
Justify—Spacing out the line; setting different sizes of type to each other.

KISS—Rollers coming into contact.
Knocking-up—Making sheets lie evenly over each other.

LAY OF CASE—Arrangement of type in case.
Leads—Lead slips used for putting spaces between lines.
Linotype—Type-setting machine, producing solid lines.
Locking-up—Wedging type in chase.
Long Primer—Size of type (10 points).
Lower-case—Small letters of the alphabet; the case used for the small letters.
Lye—A type-cleansing liquid, usually made of potash.

MS.—Author's copy.
Make Even—Finishing copy at end of line.
Make-up—Putting type together into pages or size of job.
Making Ready—Preparing tympan or impression cylinder for printing.
Matrix—Mould of type or plate.
Measure—Length of line, expressed in ems of pica.
Minion—Size of type (7 points).
Minnikin—Size of type (3½ points).
Modern—Plain Roman type.
Monk—Black spot on sheet, caused by inkstain or other dirt.
Monotype — Machine which moulds, casts, and composes type in single letters.

N.P.—New paragraph.
Nicks—Marks on front of type shank.
Nonpareil—Size of type (6 points).

O.S.—Old style. Modern imitation of antique type.
Octavo—Sheet folded into eight leaves.
Outer Forme—Forme containing first and last pages of a sheet.
Overlay—Sheet patched to produce good impression.
Over-run—Altering the measure of type to take in corrections, or to go round an illustration.

PACKING—Sheets of paper and blanket in tympan or on cylinder to graduate impression.
Pearl—Size of type (5 points).
Pitch—Adjustment of type to cylinder.
Pica—Size of movable type first used; standard of measurement (12 points).
Pie—Type thrown into disorder.
Planer—Flat block of wood for levelling down type.
Platen—Impression plate of hand press or machine.
Point—One-twelfth of pica.
Points—Steel pins fixed on forme to secure register of pages.
Process Blocks — Illustrations produced by a photographic process.

QUADS—Spaces larger than em.
Quarto—Sheet folded twice, giving four leaves.
Quoin—Wedge for locking type in chase.

RACKS—Holders for cases, chases, and tools.
Reader—A corrector of proofs.
Register—Printing pages of one leaf on the back of each other.
Reglet—Wood slips for spacing full lines.
Rollers—Ink distributors.
Roman—Common type, not *italic.*
Rotary—Type-cylinder machine.
Rough Proof—Rough impression of type pulled for correction.
Ruby—Size of type (5½ points).

SANSERIF—Form of type without fine strokes at terminations of lines. Like this: SANSERIF.
Screw-chase—Chase fitted with screws for locking up instead of wedges and quoins.
Serif—Fine lines at ends of letters.
Setting-stick—Tool into which the compositor sets type.
Setting-rule — Slip of brass against which the compositor sets, shifting it line by line.
Shooter—Wedge for driving quoins.
Sidenotes—Notes on margin of page.
Sidestick — Half-wedge laid on side of page for locking-up.
Signature—Printer's letter to mark number of a sheet—*i.e.*, in a book, &c.
Small cap.—Capitals same depth in face as lower case.
Small Pica—Size of type (11 points).
Slur—Defective impression.
Sorts—Special letters of a fount.
Spaces—Type without face for making space between words.
Superiors—Index figures or letters, very small, and cast to range with top of letters.

TAKE—A share of copy.
Thick Space—Space, three to the em.
Thin Space—Space, five to the em.
Tweezers—Small pincers for picking out letters.
Tympan—Parchment-covered frame on hand press that carries the sheet on to type.

UNDERLAY—Sheet or patchings put under type to regulate impression.
Upper-case—Capitals; the case used for capital and small capital letters, figures, etc.

VIBRATOR ROLLERS—Rollers conveying ink from ductor to ink slab.

WAVER ROLLERS — Rollers set diagonally to distribute the ink.
Web Machine—Machine supplied with paper from a reel.
Wrong Fount — Letter of different character from the fount being used—marked w.f. on proof.

Group 29
TRANSIT
23
SHIPBUILDING following RAILWAY MANAGEMENT from page 5109

THE SHIPS OF THE WORLD

Shipbuilding. The Evolution of the Modern Ship. Early Types of Ships. Sailing and Steam Ships. Wood, Iron, and Steel Ships

By Dr. J. BRUHN

THERE are few professions more interesting and fascinating than that of the shipbuilder. To be familiar with all the various details and conditions affecting the immensely complex floating structure that constitutes a modern ship requires a general knowledge of nearly every natural law, and more or less proficiency in other branches of engineering science. Moreover, its connection with the sea will probably, to most young minds, give this profession additional charm. The builder of ships has existed almost as long as the builder of dwellings; he has held as honourable a position in human society, and added his share to the progress of the world, although his material was not, in the past, so durable as that of his brother builder on land; and his structures have, therefore, and on account of the precarious nature of the sea, not been left for successive generations to admire.

How to Become a Shipbuilder. One who wants to become a shipbuilder ought, in the first instance, to aim at a sound general education. It will form the broad basis for the specialised knowledge required to grasp the principles underlying all the many intricate problems with which a naval architect is called upon to deal, and it will give the breadth of view necessary to ensure progress by the throwing off of the fetters of inherited methods, when such action is desirable. Having acquired, as far as possible, a good general education, the best way to become a naval architect is to begin to serve an apprenticeship in a shipbuilding yard. All the technical teaching at schools and colleges cannot be a substitute for the practical training in a place where actual building operations are being carried on. A general knowledge of ships and the art of building them will be acquired during the apprenticeship prior to beginning theoretical studies, and it is desirable that this should be the case, as it is only while engaged in such real work, that the want of other knowledge makes itself felt, and the want of it is a great lever in acquiring it. It is desirable that the apprentice should get as all-round a training as is possible in the various branches of this many-sided profession, but the chief weight ought to be laid on the operations connected with the manipulation of the main structural material. Having become fairly familiar with practice, the apprentice may profitably begin his theoretical training either by being alternately at the shipyard in the summer and at college during the winter, or by being engaged at the works during the day and studying at night. In thus alternating the instruction, the two sides will naturally complement each other, and a one-sided training will be avoided. With regard to the selection of technical subjects to be studied, it will be well not to confine it too narrowly to those more directly connected with shipbuilding. Mathematics ought to be given a leading position. This subject is, unfortunately, often looked upon as something of no practical value. This view originates in the failure to appreciate its nature and its bearing upon practical questions. Mathematics is, in reality, merely the instrument of all rational comparisons and estimates when they are of so complex a nature that none but a genius could carry them out by a direct inspection. As an instrument, mathematics requires careful handling and a mind to guide it. It cannot be worked mechanically with success. Statics, dynamics, kinematics and all the other branches of applied physical science are built up entirely upon mathematics. The knowledge of this subject is, however, valuable not only on account of its direct application, but it trains the mind generally to work logically or rationally. In addition to applied mechanics it will be well for the student to fortify himself as far as possible with a general knowledge of the other branches of engineering, such as civil, mechanical and electrical engineering.

The Evolution of Shipbuilding. The practice of the art of shipbuilding represents the sum of the knowledge of the past on that particular subject, and it is indispensable to be familiar with it. But, in addition, a knowledge of how it was arrived at by successive modifications in previous practice is also of great value to the naval architect, as it will enable him better to formulate reasonable opinions as to how the practice will develop in the future, while he himself will be connected with it.

In a course of instruction like the present it is, therefore, desirable to begin with a historic outline of the art of shipbuilding, showing broadly how it arrived at its present-day conditions. Following this a description will be given of modern steam and sailing vessels, to give a prospective naval architect a general idea of existing ships before he seeks to know how to build new ones.

From the earliest times ships have played an important part in the progress of the world. In them the sparks of civilisation were carried from established centres to other lands, as they carried with them a sacred fire kindled at the home temple. They have then spun the threads of attachment between mother and daughter civilisation until the latter grew up to become independent. This function of the ship as the tie between nations has been well described by John Ruskin, when he says: "The nails that fasten together the planks of the boat's bow are the rivets of the fellowship of the world."

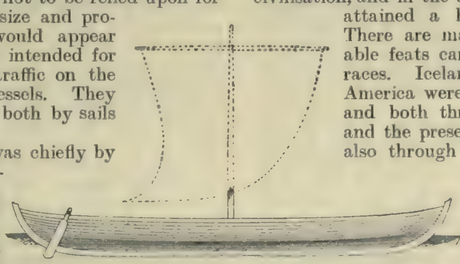
The Cradle of Shipbuilding. It is probable that the early civilisation of the plains of the Euphrates and the Tigris created some measure of shipping on the rivers and in the Persian Gulf; but it was not until the development reached the eastern shores of the Mediterranean that the production of sea-going ships became common. Here stood, therefore, the cradle of the ancient shipbuilding which should develop into the modern industry. The Phœnicians, who inhabited the strip of sea border nearest to the Babylonians and Assyrians, naturally became the first to build ships and make extensive voyages in them across the seas,

where they founded colonies and created cities at the most distant parts of the Mediterranean. It was only through their shipping that the Phœnicians became such a powerful nation, the traces of which remain to this day. In addition to their country's favourable position they possessed an abundant supply of excellent shipbuilding material in the forests of Lebanon. What their ships were exactly like we cannot say, but from the fact that they made long voyages we can conclude that they must have been of a fair size and reasonably strongly built. The Egyptians, with their high civilisation, found it necessary to employ ships even for extensive voyages, although most of their shipping was no doubt carried on on the Nile. More information exists with regard to the Egyptians' ships than those of the Phœnicians, as the former were in the habit of recording much interesting information in the highly durable material of the Libyan stone. The pictorial representations of ships that have been preserved in this way are, however, not to be relied upon for exact information as to size and proportions. These ships would appear to be more sailing barges, intended for carrying on the heavy traffic on the river, than sea-going vessels. They were, as a rule, propelled both by sails and oars.

Greek Ships. It was chiefly by the ships of the Phœnicians that the earlier civilisation was carried across the Mediterranean to Greece. The Greeks did not, however, improve much upon the ships of the Phœnicians, although their shipping developed considerably from the necessity of keeping in contact with all the many colonies they founded on the coast of Asia Minor and Africa. The ships of the Greeks have often been found pictorially represented upon the vases of that day which have been unearthed in recent times. But, as in the case of the Egyptian ones, these representations cannot be relied upon for exact information regarding size and proportions, as they consisted of more or less conventional outlines intended more for decorative purposes than for correct information with regard to the ships. It would appear that these vessels must have been small—at any rate, compared with more modern ones. Usually they were practically open or without a deck to protect the crew and cargo from the weather. They were probably propelled by sails only when the wind was right aft, as the art of utilising a beam wind to the greatest advantage was not discovered until later. The land was rarely left out of sight on the voyages, a course being followed from promontory to promontory. From Greece, civilisation was again carried westwards, this time to Italy, by means of ships, and the Roman republic, later on the Roman Empire, became the centre of the world's maritime as well as other interests. Like the Greeks, the Romans carried on extensive intercourse with their colonies in Africa and Spain. For a long time a keen rivalry was carried on with Carthage, which owed its foundation to the earlier activities of the Phœnicians, but eventually the Carthaginians were subdued.

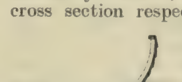
Roman Ships. The ships of the Romans were to a greater extent imposed by immense activities in other directions than objects constructed for the love of maritime pursuits. Their character remained very much the same as that of the Greek ships. They were more like land structures made to float than shipshape creations. Above the water they were of a fantastic construction, with erections for fighting-men, protective hoods for officers, etc. At the waterline they had rams for damaging the vessels of the enemy, and rows of long oars gave them the appearance of huge multipedes. The Roman colonies in Spain and in the South of France became after a time more directly interested in shipping than the mother country. The inhabitants of the west coast of France were particular adepts in the art of shipbuilding, according to the very circumstantial reports written by Julius Cæsar while extending the power of Rome in these regions.

The Ships of the Vikings. About the time of the fall of the Roman Empire an independent development in shipbuilding took place elsewhere. The people who inhabited Northern Europe had by this time also developed a considerable amount of civilisation, and in the art of shipbuilding they had attained a high degree of perfection. There are many records of the remarkable feats carried out by these northern races. Iceland, Greenland, and North America were reached towards the west, and both through the English Channel and the present Straits of Gibraltar, and also through the rivers of Russia, the Mediterranean and Black Sea were reached.



1. VIKING SHIP

Less is known of the buildings erected on land by these people than of those in the south, as they were of wood, easily subject to decay and fire. On the other hand, more is known about the ships in the north, as it was there a frequent custom to bury, with a dead chief, in huge mounds of earth, his ship and other things belonging to him. In recent times two vessels have thus been found, and others have been discovered in wood-preserving peat bogs. In this way, very reliable information is obtained with regard to the ships of Northern Europe at that date. One of these viking ships, as they are called, was discovered in Norway in 1880. It is represented by **1** and **2**, which show a side view and a cross section respectively of the restored vessel. She was 78 ft. long, 16 ft. 7 in. broad, and 5 ft. 9 in. deep. The keel was the main timber, being 14 in. deep and 4½ to 7 in. thick. The vessel is what is called *clinker built*—that is, the outside planks overlap each other, as shown by **2**, and as is usual now in the case of rowing boats and other lightly-built crafts. The planks are only 1 in. thick, and are clinched together with iron nails. They are, however, not clinched to the frame timbers in the now usual way, but are tied to them by means of tough roots. The necessary holes in the planks for this purpose are made in thick protuberances, left on the inside when the wood was prepared. By this ingenious method the builders avoided the necessity of having holes in the outside planks, at the back of the frame ribs, where a leak would be liable to occur, and where it could not be readily got at and stopped. The foundation for the mast, which was a heavy concentrated weight to be carried in a craft of so light construction, was of a design that



2. VIKING SHIP, CROSS SECTION

has hardly, if at all, been improved upon in the most modern yacht construction, where the same problem of distributing a concentrated weight over a very light structure has to be dealt with.

Early Efficiency in Construction. These early shipbuilders were also well aware of the principle that where a minimum of material is to be sufficient, there must be a high degree of excellence of workmanship. It may be doubtful whether vessels have at any time been built which, taken all in all, were more efficient for the intended purpose than these viking ships of a thousand years ago. They possessed the highest degree of strength with the minimum of material. Lightness was of the greatest importance in these vessels from the fact that they had often to be hauled up on land. So easily were they handled that it is even recorded that on occasions when something could be gained thereby, they were transported on rollers for considerable distances on land. They had to be propelled by oars, to be able to run up rivers and creeks, and at the same time they could utilise the wind when it was well aft. The general form adopted to give sufficient stability and a minimum of resistance to propulsion under these conditions is such that it would be practically impossible to improve upon it now, in spite of all the development of modern science.

The deep keel is designed in the most efficient way to protect the vessel when taking the ground, which was necessary when landing was effected in those days of no harbours. The rudder is hung on the starboard, or right side, of the vessel, and could easily be unshipped, and would in any case, with the arrangement adopted, take no damage if touching the ground. It is practically the same arrangement as that adopted in many lifeboats of the present day, designed with a view to the difficulties encountered in landing on an unsheltered shore. In these swift and handy vessels the Vikings swept down upon the remainder of Europe, and the influence of the North was being carried to the eastern shores of Great Britain at the time the Romans were still keeping up communications with the southern ones. The intermingling of the ideas of the classical nations with those of the North may not have been without influence on the development of the maritime affairs of the country which was to become, in modern times, the centre of the world's shipbuilding industry.

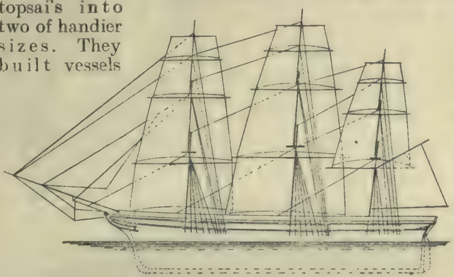
Ships of the Middle Ages. During the early part of the Middle Ages, shipping interests were still chiefly centred in the Mediterranean. It was more particularly the Italian republics that developed the maritime pursuits. The Venetians possessed an extensive fleet of merchant vessels, and kept up a brisk trade with the East. Their ships were, however, more fantastic and picturesque than highly efficient, and no very radical improvements were introduced. The Genoese were, later on, the keen rivals of the Venetians. In Northern Europe the Hanseatic League took the lead in maritime affairs. There was, however, right through the Middle Ages, very little development in the art of shipbuilding. The old ideas were perpetuated, and ships remained very much of the same character as before. With their fantastic trappings, and with their often irrational designs, they were not nearly so efficient for their purpose as the earlier ships of the vikings.

The Genoese were the first to use more scientific methods of navigation, and more rational methods in handling their ships. They are usually credited with discovering the way to utilise a beam, or side wind, to the greatest advantage. With that discovery the use of oars as a means of propelling seagoing vessels ceased to be a necessity, and the time became ripe for the extensive navigation of the high seas. It was at this time that Columbus, after leaving Genoa, prevailed upon the King of Spain to fit out the expedition that led to the discovery of America. This was, however, only one of a long series of discoveries made by Spanish and Portuguese sailors, and, as a consequence, the centre of shipping interest moved again westwards. When Spain and Portugual declined, the Low Countries took the lead, and finally it passed to England. At this time, improvements in ship construction were still very slow. The general character of the ships remained unchanged, although the increased experience caused modifications in details.

Developments in the Nineteenth Century. The very earliest ships were propelled entirely by oars, and for ages this method of propulsion was retained as a stand-by when there was no wind. Eventually, with the increased knowledge of how to manage the sails, the use of oars was discarded for seagoing vessels. By the beginning of the nineteenth century the steam engine had been invented, and put to use for various purposes on land. It was not long before it was realised that there was here a power which might, with advantage, take the place of the sails and the uncertain wind as a means of propelling ships. The idea of providing a vessel with the power to move it by other than human labour occurred even to the Romans, who, it is reported, had some vessels propelled by paddle wheels worked by oxen. It was not, however, until physical science, in the eighteenth century, had developed sufficiently to make a reasonably efficient steam engine possible that the employment of mechanical power for the propulsion of ships became common. For a long time after the introduction of steam power into ships sails continued to be used in the majority of vessels, and even in those where steam engines were fitted, sails were extensively carried in those days as a stand-by in the event of the coal giving out or the engines failing. The outline of the history of the sailing ships may therefore be continued up to the present day, before the evolution of the steamship is sketched.

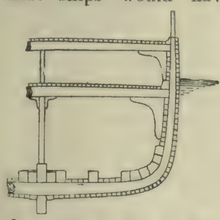
East and West Indiamen. In the early part of the nineteenth century a rivalry sprang up between England and the United States of America in the matter of shipping similar to that which had existed between Greece and Rome and their respective colonies. The English merchant vessels were up to this time built entirely on the old, established lines. They were of bluff forms at the ends and consequently of slow speed. On the other hand the underwater part amidships was of a rounded form which did not admit of a large amount of cargo being carried in a vessel of given dimensions in spite of the fulness of the extremities. In the rig and general arrangement these vessels still retained some of the old fantastic features, then thought to be indispensable in a ship. This type of sailing vessel was best represented by the so-called "East Indiamen," owned by the old East India Company, and trading to the East. They carried a relatively small cargo, and a large crew, and could be utilised as ships of war if required. Later on another type developed—namely, the so-called West Indiamen—which were somewhat more efficient from a commercial point of view as they carried a larger amount of cargo, and had a much smaller crew.

American Influence on Sailing Ship Construction. In the creation of a more efficient type of sailing ship the Americans came to contribute considerably. They had the great advantage over the inhabitants of the mother country of being a young nation unfettered by previous conventional ideas with regard to the construction of ships. In addition to this advantage the Americans were favoured by abundant supplies of wood conveniently at hand. It was therefore natural that they should take the lead. In the first instance they improved the speed of ships by making the form of the vessel sharper towards the extremities, while they at the same time increased the cargo-carrying capacity by making the form amidships straighter in the side of the vessel and fuller under water. In other words, they utilised the space better than had been done before, and made a vessel of given dimensions more efficient all round. The Americans also introduced labour-saving appliances in the handling of the sails. They were thus the first to divide the large square topsails into two of handier sizes. They built vessels



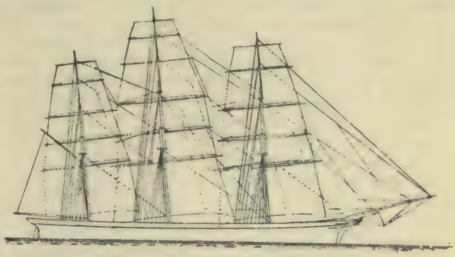
3. EARLY AMERICAN WOOD SHIP

of larger tonnage, and relatively longer, than had been done before, and as the sails which these ships would have required, if provided with only the usual three masts, would have been too large, they introduced an additional one. Figures **3** and **4** show a typical example of American wood sailing ships of the period just prior to the introduction of the double topsails. Before the introduction of railways across the continent an extensive trade was carried on by these sailing ships between the Eastern States and California, and some famous passages were made on this extensive course right round Cape Horn.



4. SECTION OF EARLY AMERICAN WOOD SHIP

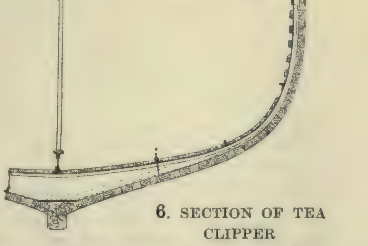
Tea Clippers. The English and Scotch shipbuilders were not slow to adopt these improvements in their new vessels, and in the race from China with tea for the London market the English shipowners were soon able to beat the Americans. These so-called *China clippers* were the fastest merchant sailing vessels built. As the ships of the Vikings came to mark the final development in the combined sailing and rowing seagoing craft, so the China tea clippers may be considered as the highest development of the pure sailing-ship type. They carried on the last struggle of sails against steam in the quick transit across the ocean. After that date sailing ships continued to be built, and they are still being built, but only for trades where cheapness of transit is of greater importance than speed. From this point of view of sailing efficiency, there has been little improvement, if any, since the tea clippers were built. The



5. TEA CLIPPER

modifications that have taken place have been in the direction of the economical working and building of the ships all round and in the direction of carrying a larger amount of cargo in a vessel of a given length, breadth, and depth. Figures **5** and **6** represent one of the most famous tea clippers. It will be noted that the spread of canvas is very large in proportion to the size of the vessel. The form of the midship cross section [**6**] shows by its fineness that they could not carry a large amount of cargo, particularly as the form was also very sharp towards the ends of the vessel. They were of the so-called *composite* construction, where the frames, beams, and general internal structure are of iron and only the outside planking and decks of wood. This arrangement was adopted in view of the difficulty of obtaining the necessary strength by a purely wood construction in vessels of such fine form and lofty rig.

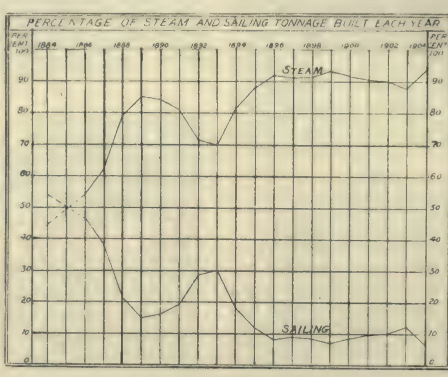
Warships. While the merchant sailing ships developed, so also did warships, but to a much smaller extent. Owing to the large crew that these ships always carried there was not the same inducement to reach a higher degree of efficiency in the arrangement and handling of the sails and in the general working of the vessel. The weight of the

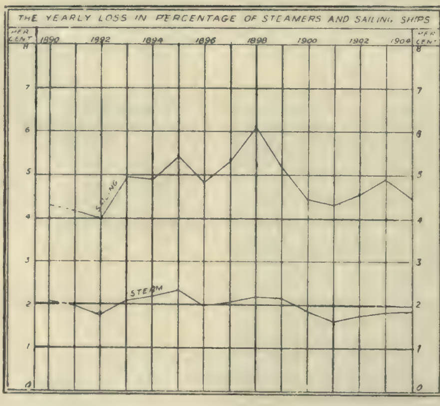


6. SECTION OF TEA CLIPPER

structure was also not of the importance it is now in a warship. On the other hand, height of platform for handling the guns was essential, and also

handiness in manœuvring. The consequence was that the wooden sailing men-of-war retained to the last their short, towering, bluff form that can yet be seen at the mouth of most English rivers, where these vessels are now commonly used as training ships for boys. It was such a beautiful ship of the line that inspired John Ruskin, when he wrote of man's capabilities as a gregarious being: "Into that he has put as much of his human patience, common-sense, forethought, experimental philosophy, self-control, habits of order and obedience, thoroughly wrought handwork, defiance of brute elements, careless courage, careful patriotism, and calm expectation of the judgment of God, as can well be put into a space of 300 ft. long by 80 ft. broad."



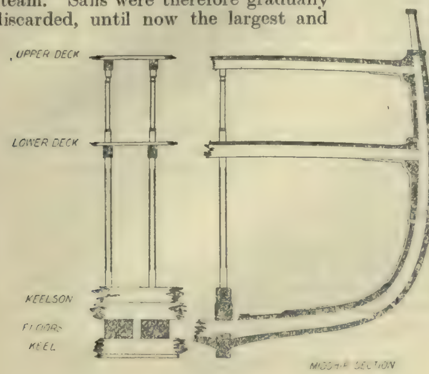


Steam Propulsion. It was not until the steam engine had reached a certain amount of efficiency that its introduction into ships as the propelling power could become profitable. That point may be said to have been reached by James Watt's invention of the double acting engine. The idea of utilising the power of steam for ship propulsion originated in several minds, probably more or less independently, but Symington may be said to have first realised it in the Charlotte Dundas, a small steam vessel which made its trial trips on the Forth and Clyde Canal in Scotland, in 1802. It was appropriate that the River Clyde should thus see the birth of the first mechanically successful steamer, as this river should afterwards become the world's centre for the production of steamships. It was not, however, until the year 1807 that Robert Fulton, in America, succeeded, by the vessel Clermont, in producing a commercially successful steamer, which could ensure and did ensure the continuous development of steam power as applied to ship propulsion. The beginning of commercial steam navigation took place, therefore, on the other side of the Altantic; but it was not long before steamers were extensively adopted by British shipowners, and it was by the growth of its steam tonnage that the British mercantile navy should reach the enormous development during last century whereby it outdistanced by far the fleets of all other nations. To begin with, the dimensions of steamers were small. Those of the Clermont were: length, 130 ft., and breadth 16½ ft. Only vessels for rivers and sheltered waters were fitted with the new power of propulsion.

Paddle and Screw Steamers. After a time had elapsed steam was, however, also applied to ocean-going vessels. So far the only method of applying the power had been by means of paddle wheels on the sides of the vessel, and although these proved themselves very satisfactory for river steamers, they were not so for ocean-going ships, where the large wheels were exposed to the blows from the seas and where the rolling might often alternately dip the wheel on one side too deep in the water, or lift it entirely out of the water, in both of which cases the propelling power would be largely lost. In 1839, the screw propeller had been invented by Mr. Smith, and was applied to the Archimedes, a vessel of fair size. This was a great improvement in the method of propulsion as applied to ocean-going steamers, because the screw could be placed low down in the water, where its action was less liable to be interfered with by the movements of the ship or the waves. Although paddle steamers were at that time crossing the Atlantic, they soon died out for that purpose, and the screw propeller has been victorious down to the present moment. Since its introduction the developments have been gradual, and have been principally in the direction of improved engines and boilers. The greater efficiency of the propelling machinery was obtained chiefly by a continuous increase in the pressure of the steam in the boilers and by its more economic use in the engines, first by passing from the simple double-acting arrangement to compound engines, then to triple expansion, and, finally, to quadruple expansion. The principle of the multiple expansion of the steam as it passes from the maximum pressure in the boiler to the minimum in the condenser is simply to get a more gradual, and therefore more economical, supply of work from the steam. This question will, however, be dealt with under Prime Movers. The very latest method of applying the power of steam to ship propulsion is by means of turbines, where reciprocating machinery is entirely done away with, and the steam is made to act directly on a rotary fixed to the propeller shaft much in the same way as water acts on a horizontal turbine wheel, or the wind on the sails of a windmill. By this method the propelling agent remains the screw, but it is usually found advantageous to employ a greater number of them than before—usually two, three, or four are fitted.

Discarding Sails. The first ships for ocean-going purposes to be fitted with steam retained their full complement of sail, in order to save coal when the wind was favourable and to have a stand-by should the engines break down. By the development of more economic, particularly more coal-saving, machinery, and by its

being perfected so as to be more reliable, the use of sails became of less importance. In many instances where the speed was high the tall masts, yards, and rigging added materially to the resistance, and reduced, therefore, the speed when under steam. Sails were therefore gradually discarded, until now the largest and most important steamers have only masts for the purpose of carrying signal flags and lanterns, or for supporting cargo derricks. The introduction of the twin screw, with its two independent sets of engines, gave increased safety, and aided in bringing about the above-mentioned result. The consequence is that not only are sailing ships disappearing rapidly, but sails for other than steadying purposes are also vanishing, or have vanished, from steamships.

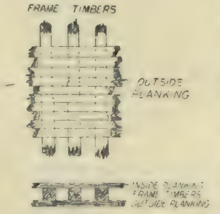


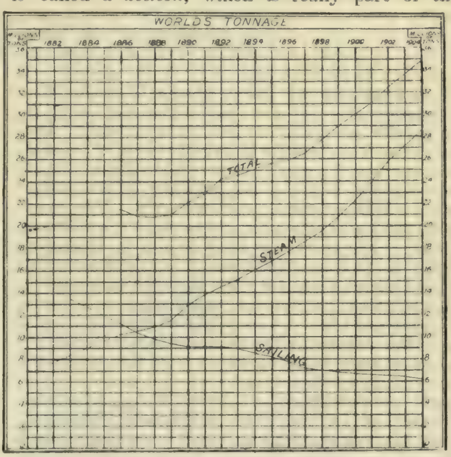
7. USUAL CONSTRUCTION OF WOOD SHIP

The Disappearance of Sailing Ships. The extent to which sailing ships are still being built is shown graphically by the upper diagram on the preceding page. The bottom curve gives the percentage of sailing ship tonnage built throughout the world in each year, the top curve the corresponding percentage of steam tonnage. the horizontal divisions representing years and the vertical divisions 10 per cent. It will be seen that the growth in the production of steam tonnage has been enormous, particularly in the years just before 1889. The increase in the percentage has, however, not been steady, as is seen by the fall in the years from 1889 to 1892. During recent years there has been a tendency for the percentages to be more constant, the steam tonnage remaining at about 90 per cent. and the sailing ship tonnage at about 10 per cent. The second diagram shows the relative yearly waste of steamers and sailing ships. It will be seen from this diagram that the average yearly loss in steamers is about 2 per cent. against about 5 per cent. for sailing vessels.

Taking ships on the whole, and ignoring age and material of construction, a steamer may be said to have fully twice the vitality of a sailing vessel. The effect of the yearly building and loss upon the existing tonnage of the merchant fleets of the world is shown in the table in next column, the horizontal divisions representing a year, while the vertical divisions are equal to 1,000,000 tons. It will be seen that in the year 1887 the existing sailing ship and steamship tonnage were equal, but the steam tonnage was in the ascendancy, while the sailing ship tonnage was dwindling. The increase in the steam tonnage has been very steady, and the decline in the sailing ship tonnage has been equally so. In twenty to thirty years from now, sailing ships will be an entirely negligible quantity in the mercantile fleets. The top curve shows the entire tonnage of the world, and it will be observed that it is growing by more than a million tons a year. These curves are derived from the careful statistical records kept by Lloyd's Register of Shipping.

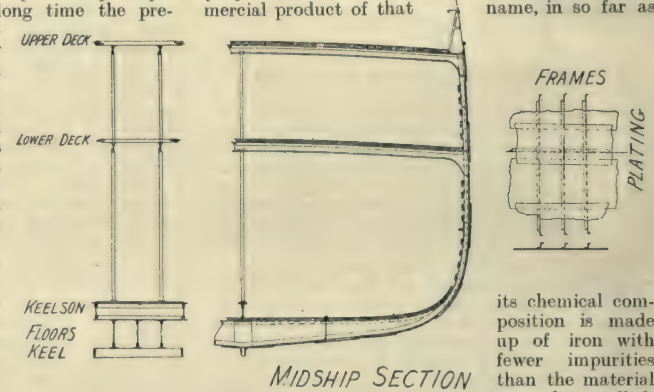
Wood Ships. From the earliest times right up to the beginning of the nineteenth century all ships had been built of wood. This was naturally the material that suggested itself first from its ability to float on the water. For centuries it was supposed that this ability of a material to float was essential to its use in the hull of ships. This idea was, as a matter of fact, wrong, which could be proved by the ability of any tin or light iron kettle to remain floating on the water. In many respects wood was an excellent material for shipbuilding purposes, particularly as long as ships remained of moderate sizes, and under any circumstances it was the only possible material until comparatively recently. Oak and other hard woods were the best for the purpose, but pine was often more conveniently at hand, and cheaper. The general method of construction of wood ships has remained the same as far back as it can be traced. A heavy piece — or pieces — of timber form the keel or backbone of the structure. On it are erected floors and frames, or stiffening ribs. To these the outside planking is attached, as indicated in 7, which represents a midship section of a wood merchant ship. At the top of the frames the beams are fitted across the vessel. In the case illustrated. there are two tiers of beams, one to carry the upper-deck planking, and one to take a deck lower down for the accommodation of passengers or cargo. The frame timbers are planked on the inside to keep the cargo dry. Above the keel, heavy timbers are run along on the top of the floors forming what is called a *keelson*, which is really part of the backbone of the structure, being thoroughly bolted through the floor timbers to the keel. From the keelson, supports are carried up to the deck beams. It is desirable to have as few joints as possible in the structure of a wood ship. It is, however,





impracticable to obtain timber of the form and size necessary to dispense with all joints, and in some instances, as in the case of the frames, it is necessary to have each set of timbers built up of a number of comparatively small pieces, which must then be bolted together. This question of the joining of the individual parts is one of the most difficult ones in wood ship construction, as will be evident from the large wrought iron knees shown in **7**, attaching the beams to the sides of the vessel. A very large amount of iron has in this way to be worked into the structure, whereby it becomes so heavy that it would not float if pierced, in spite of the general material being wood. Gradually more and more iron was in this way being used in ships.

Iron Ships. About the same time as steam power was beginning to become general for the propulsion of ships, another epoch-making change was being prepared. Barges were being built of iron plates on the principle of the steam boilers. As they were found to answer satisfactorily, it was proposed to adopt this principle for sea-going ships. For a long time the prejudice against such an unheard-of proposal was sufficiently strong to keep the suggestion from being carried out in practice. Eventually the general superiority of iron as a material for shipbuilding purposes was recognised, and the enormous development of modern shipping became possible. As Great Britain had taken the lead in the change from sail to steam, so it also became the shipowners and shipbuilders of this country that first realised the immense possibilities of the introduction of the new material. One of the first iron vessels, the Vulcan, was, appropriately enough, built on the Monkland Canal, near Glasgow, in the year 1818. The first iron steamer, the Aaron Manby, was constructed in 1821. From that year up to about 1885 the construction of iron ships increased to such an extent that the new material practically displaced wood.

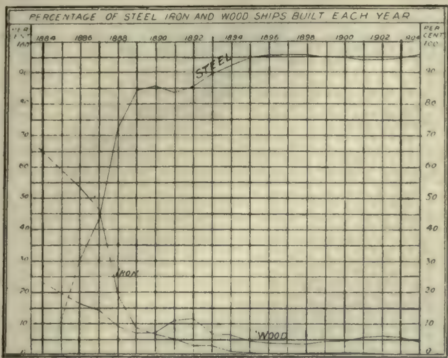


8. CONSTRUCTION OF IRON SHIP

Superiority of Iron Over Wood. The superiority of iron over wood lies not only in the greater strength of the material itself, but also in the fact that the individual parts of an iron structure can be much more effectually attached to each other, whereby the efficiency of the structure as a whole is immensely increased. Moreover, a considerable saving in weight is effected by the use of iron. The specific density of iron is, of course, much greater than that of wood, and, bulk for bulk, iron is therefore heavier. Its strength is, however, more superior to that of wood than its specific weight is greater. A less weight of iron will therefore suffice to produce the same strength as a greater weight of wood. In a general way the structural arrangement of iron ships was the same as that adopted in wooden ships. Figure **8** shows the construction of an iron ship. Comparing it with **7**, it will be seen that the keel and keelson still form the backbone of the structure; the floors and frames are fitted as in the wood ship, and the beams and decks are similarly arranged. In lieu of the outside planking, comparatively thin plating is now fitted. It will, however, be observed that although the general arrangement is similar, the dimensions of the individual parts are reduced very much. For instance, where the outside planking was 4 in. in thickness, the iron plating is only about ½ in., and where the floors were some 12 in. thick, they are now less than half an inch. Iron is so infinitely superior to wood as the material of construction for large sea-going vessels, that the long, shallow, and fast ships now existing may be said to have been an impossibility without the introduction of the new material. A splendid proof of the possibilities of iron was to be furnished not long after its general acceptance as a shipbuilding material, but the vessel in question will be referred to later. In the meantime, it will be desirable to mention the second great change in the material of construction.

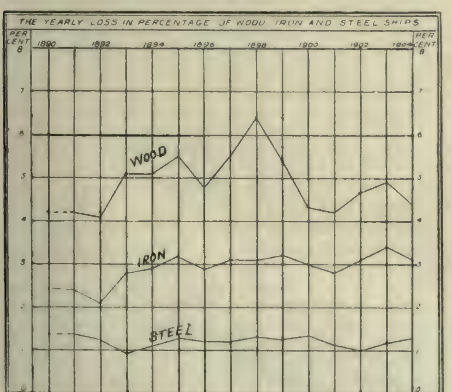
Steel Ships. About the year 1875 an improved method of manufacturing iron plates and angles had been invented. The new product was called *mild steel.* It must not, however, be confounded with the hard material used for tools and similar objects. In reality, the steel used for shipbuilding purposes is more real iron than the commercial product of that name, in so far as its chemical composition is made up of iron with fewer impurities than the material properly so called. The essential difference between iron and steel for shipbuilding purposes is this, that the latter is stronger, more uniform in quality, and more pliable. It can be given almost any form, to a large extent without the application of heat, which is usually necessary in the working of iron. The introduction of steel was therefore a great improvement, but it did not represent nearly so great an innovation as the substitution of iron for wood; it merely accentuated the advantages of metal over wood. Although both iron and steel are on the whole infinitely superior to wood, they have certain disadvantages. In the first instance, they corrode, particularly so where subjected to the action of the impure water that always gathers in the bottom of ships. A little experience with iron ships proved this, but it was not long before it was realised that a little care and the application of paint and cement practically removed that trouble. Wood ships, particularly those trading in the tropics, were always subject to having the exterior of their bottoms covered with barnacles and other marine growths, which could assume huge proportions and delay the progress of the vessel considerably. It was discovered that by covering the bottom below the water-line by thin copper plates these growths were prevented from attaching themselves to the ship. This expedient was therefore universally adopted in all first-class wood ships. When iron

was introduced, the trouble with the growths cropped up again. It was attempted to attach copper plates to the iron bottoms as in the case



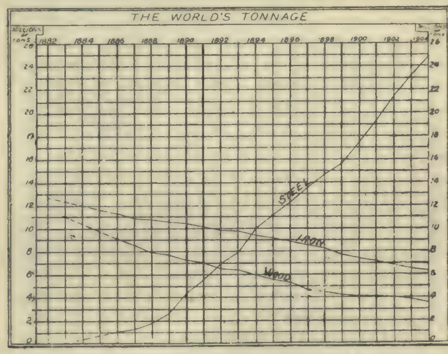
of wood ships, but with disastrous results, as the two metals set up a galvanic action which consumed the iron. Again experience soon taught that iron ships required a slightly different treatment from wood ones. The more frequent docking and cleaning, and the use of more or less efficient anti-fouling paints, practically removed the difficulty of the barnacle-covered bottom in iron and steel ships.

Number of Vessels of Wood, Iron, and Steel. The effect of the change from wood to iron and from iron to steel in the amount of shipping created each year will be seen at a glance from the diagram above, where the three curves represent the growth or decline of the three materials in percentage of the total amount of tonnage produced each year. It will be observed that iron had already, in 1886, reduced the production of wood ships to about 16 per cent. of the total output of the world, but even this figure has by the combined effect of iron and steel been reduced to only about 4 per cent. in 1904. On the other hand, the immediate effect of the introduction of steel was to make the iron ship disappear even more quickly than the wood one did. Since 1894 iron shipbuilding has been practically extinct, and steel ships have represented 90 per cent. of the total



production. The relatively yearly loss of wood, iron, and steel ships is shown graphically in the next diagram. It will be seen that the wastage is, on the whole, fairly constant for each material, but the iron ships are disappearing more than twice as fast as the steel ones and the wood ships more than four times as fast. The net result of the additions and deductions to the existing fleets of the world is shown in the last diagram. It will be seen that there is a very steady increase in the tonnage of steel ships and an equally steady decline in the tonnage of iron and wood ships. Some ten to fifteen years from now the wood sea-going ships will have practically ceased to exist, and in another five to ten years time the iron ship will have gone the same way.

The Great Eastern. The use of iron as building material culminated in the building of the Great Eastern, the most unique specimen of naval architecture that the world had produced. The construction and design of this vessel are well worth careful study even in these days of large steel steamers, and a short reference to them may not be out of place here. It was Mr. Brunel who first conceived the idea of building a ship large enough to steam round the Cape of Good Hope to India without coaling on the way. The Great Eastern was designed and built with a view to realise this idea. Her length over all was



692 ft.; length between perpendiculars, 680 ft.; breadth of hull, 83 ft.; breadth over paddle-boxes, 120 ft.; depth from keel to upper deck, 58 ft. Her tonnage was 22,500 and the displacement 30,000 tons, at a draught of 30 ft. She was capable of carrying 18,000 tons of coal and cargo, and in addition she had accommodation for 4,000 passengers or 10,000 troops. She was propelled by two sets of engines, one working a four-bladed screw propeller 24 ft. in diameter, the other a set of huge paddle-wheels 58 ft. in diameter. In addition to the two sets of engines she had 195,000 square ft. of sails. The Great Eastern was begun in 1854 and launched in 1858 from the Isle of Dogs, near London. Figure **9** shows a side view of the vessel, and **10** a midship cross section. In many respects this wonderful ship led the way in naval architecture. In some directions she was so much ahead of her time that it was not until many years after that her lead was followed. In some points this has not been done to this day.

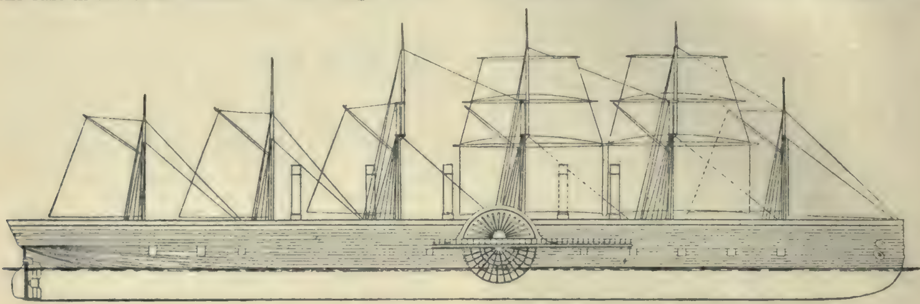
Difficulties in the Construction of Large Vessels. The construction of a large ship involves far more difficulties compared with that of a small one than does the building of a large house compared with that of a small one. For every increase in size greater power is required to maintain the same speed, and consequently greater coal capacity, etc. But the most serious

question is that for every increase in size you need relatively more structural material if the same strength is to be maintained, and where no experience has been gained, it is always a difficult problem to determine what will be sufficient strength under the new conditions.

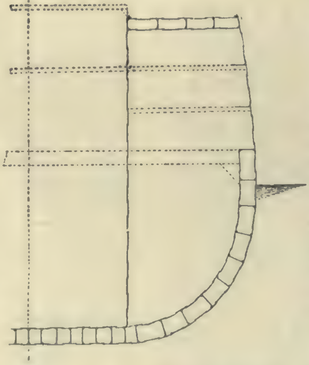
The mere creation of a huge structure is not in itself a particularly praiseworthy achievement. To be that it must be done by efficient means, as was the case in the Great Eastern. The design of her structural arrangement was a greater work of genius than even the conception of the primary idea of building a large vessel capable of steaming to India without coaling. From the very beginning of the structure all old-established conventions were departed from. The keel proper, as fitted in wood ships and as retained even until quite recently in large steamers, was dispensed with, and in its place was fitted an ordinary strake of outside plating only $\frac{1}{4}$ in. greater in thickness than the remainder of the plating, and stiffened internally by a vertical plate, all as has but recently become the usual practice.

Cellular Construction. The boldest innovation was the entire dispensing with the ordinary floors and frames as the means of stiffening the outside plating, and the introduction of a series of longitudinal girders, as shown in the section [**10**]. Brunel rightly realised that the longitudinal strength would be by far the most important in a vessel of this description, and he therefore chose not to rely only on the outside plating for strength in this direction, but he arranged the stiffening of this plating in such a way that it assisted in the resistance to longitudinal bending. Moreover, he realised the immense strength of the cellular construction, and adopted it both for the bottom of the ship, where it has now become universal, and for the upper deck, where it has not been adopted since.

The fitting of an entire inner bottom, thereby adding to the safety of the ship, was also a new idea which has now been practically universally adopted. The possibility of using the space between the two skins for the purpose of carrying water ballast was also recognised. The double bottom was in the Great Eastern extended up the side of the vessel to above the water-line, whereby additional safety was ensured. Besides the inner bottom the vessel had twelve transverse watertight bulkheads and two longitudinal ones, which added to the general strength of the entire structure, and lessened considerably the chances of sinking in case of injury. The deck giving the greatest amount of transverse strength was the one fitted at the head of the double bottom, or near the water-line, and the deck possessing the greatest amount of longitudinal strength was the one fitted at the top of the structure. Brunel thereby recognised a principle which it has taken a couple of generations to appreciate fully. Throughout the entire ship the clumsy use of individually thick plates was avoided. The necessary strength was obtained, in spite of the size of the structure, by a thickness of only $\frac{3}{4}$ in. for the entire inner and outer shell plating, and $\frac{1}{2}$ in. for the deck plating.



9. SIDE VIEW OF THE GREAT EASTERN



10. GREAT EASTERN MIDSHIP CROSS SECTION

Great Eastern Not Exceeded till 1907. To realise what the successful building of such a ship meant at that time, it must be borne in mind that the length, the breadth, and the depth were practically double the corresponding dimensions of the vessels with which experience had been gained up to that time. Throughout the fifty years which have elapsed since its construction there has been a steady increase in the dimensions of ships, but no individual ship has to this day reached the size of the Great Eastern. Two vessels are, however, now building which will exceed in dimensions in every respect those of the ship of 1858, but the engineering feat of producing a ship some six times the size of the largest existing ship is not likely to be ever again achieved in the progress of naval architecture. Unfortunately, the time was not ripe for the profitable employment of ships of such size, and the result was that the Great Eastern came to be a very costly experiment, technically a success, but financially a failure.

Continued

HOW TO USE THE INCUBATOR

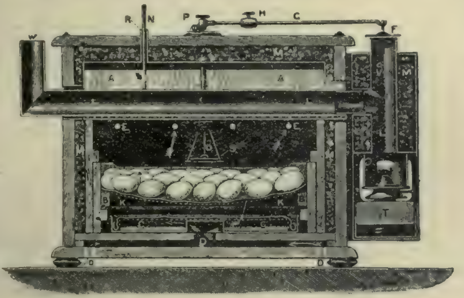
A Description of the Incubator and the Method in which it Should be Used. Some Experimental Statistics. Keeping a Record

continued from page 5094

By Professor JAMES LONG

THE difficulty of obtaining hens for sitting during the winter season, and the perfection to which the incubator has been brought, has resulted in the very general adoption of this machine for the purpose of hatching eggs. A well-constructed incubator is of great service to the poultry keeper, enabling him, as it does, to be independent of the hen to hatch chickens in large batches with almost absolute certainty, without the interference of vermin, or the necessity for outdoor work in bad weather.

Where to Keep the Incubator. There are, however, certain conditions which it is essential to observe. The apartment in which the incubator is placed should be one in which it is not possible for the temperature to fall below, say, 45° F., or thereabouts, at any time.



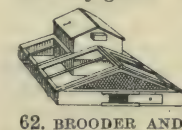
63. HEARSON'S INCUBATOR

a. Tank of water *b*. Movable egg-tray *c*. Water-tray *d*. Holes for fresh air *e*. Ventilating holes *f*. Damper *g*. Lever *h*. Lead weight *k*. Slips of wood *l*. Lamp chimney and flue pipe *m*. Non-conducting material *n*. Tank thermometer *o*. Needle for communicating the expansion of the capsule *s* to the lever *g* *p*. Milled-head screw *r*. Filling tube *s*. Thermostatic capsule *t*. Petroleum lamp *v*. Chimney for discharge of surplus heat *w*. Chimney for discharge of residual products of combustion *x*. Glass chimney, covered with asbestos. The overflow tube is the upper one, on the right-hand side of incubator, and the lower tube is for emptying the tank

It must be thoroughly ventilated, pure air being practically as essential to the vitality of the egg as to the living chicken. The larger the number of incubators employed in an apartment, the greater the importance of these conditions, especially as where several lamps are burning, there is a larger consumption of oxygen, and a greater liability to smells.

Whatever machine be purchased, the instructions of the manufacturers should be carefully studied, and every detail mastered before valuable eggs are placed within it. Among these details, the management of the lamp, and of the drawer, as well as of the ventilation of the eggs, should be specially noted.

In marking eggs, it should be remembered that they are chipped by the chicken within, at the large end through which the youngster emerges, although occasionally they are chipped elsewhere, when it may be necessary to render slight and very gentle help. The chickens hatch on the twenty-first day, but it frequently happens that eggs are chipped on the twentieth day. In the case of the duck, the goose, the turkey, the guinea fowl and the peahen, 28 days are occupied in incubation.

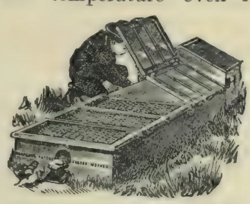


62. BROODER AND COVERED RUN

We proceed to describe the way to manage the incubator on the basis of the experience of one who has achieved much success with it.

Practical Management of the Incubator. When deciding to use an incubator, start, if possible, with a good one, such as Hearson's [63]. If the incubator be bought at a sale, thoroughly examine and test it; afterwards overhaul and clean inside and out, placing it out of doors to dry and sweeten. Obtain a good thermometer, and replace all missing parts, including the canvas in the egg drawer, and the damper if that is necessary. The capsule must not be forgotten, this being, perhaps, the principal item, for the proper working and regulating of the incubator depends upon it. Place the incubator in a small room, if possible, where it will be free from draughts, concussion, or the banging of doors. Having everything ready for a start, fill the tank with slightly warm water, and the lamp being filled and trimmed, light it and carefully watch the thermometer, controlling the heat by the aid of the regulator.

Temperature Necessary. Now keep the temperature even for three days—say, from 100° F. to 103° F.; it should at no time be allowed to rise beyond 105° F. or to fall below 98° F. The germ in an egg will bear a low temperature better than a high one; it is, however, wonderful what eggs will go through and permit the chickens to survive, although it must necessarily weaken them when the temperature is frequently "up and down" during incubation.



64. OUTDOOR BROODER WITH RUN

Place the eggs in the drawer, after marking each with the date on one side and a cross on the other, the date being upwards, then carefully close the drawer and watch the thermometer, and it will be noticed that the temperature will steadily fall, until the eggs begin to

EGGS HATCHED IN THE THREE YEARS ENDING MARCH 31ST, 1906.	1903-4	1904-5	1905-6
Number of hatches	62	68	89
Number of eggs placed in machines ..	4,590	5,881	7,790
Number of fertile eggs	3,674	4,714	6,330
Number of chickens, etc., hatched ..	2,572	3,574	4,631
Percentages of fertility	79·6	80·15	81·13
Percentages of hatches of fertile eggs ..	70·0	75·82	73·16
Highest hatching percentages	92·3	96·82	94·59
Lowest hatching percentages	50·0	56·52	34·78
Highest monthly hatching percentages ..	81·12	87·61	88·32
Lowest monthly hatching percentages ..	67·94	70·17	55·44
Tank incubators hatching percentages ..	70·89	78·2	75·42
Hot-air incubators hatching percentages	68·95	73·64	71·51

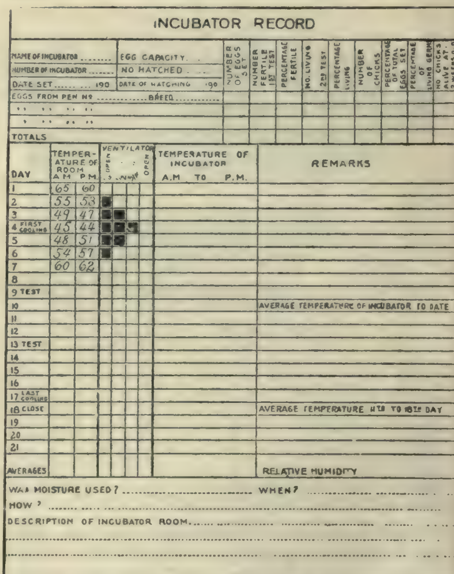
get warm. The incubator must be watched with great regularity, the eggs turned morning and evening, cooled and aired, turning being essential to prevent the germ being fixed, as it were, and thus arresting or entirely preventing development; it also makes up for any little differences of temperature which exist in the egg drawers. The eggs should be exposed to the air for about ten minutes in cold weather, or twenty minutes in very warm weather. They should be handled gently and the worker should be careful not to open the incubator more than twice in the day, especially when the chickens are nearly ready to hatch. The lamp must be filled and trimmed daily, and the tray and damper occasionally examined.

Examining the Eggs. On the seventh day the eggs should be examined, using a lamp with a strong light to ascertain if they are fertile. Thick, or dark-shelled eggs are sometimes difficult to test; in such cases, they may be left a few days and examined again. If there is still uncertainty about an egg, it may be marked, and its progress watched and compared with the rest. After thirteen days, the chicken develops rapidly, and by the twentieth day the egg is almost entirely opaque. The chicken may then be seen to move, and one may hear it tap the shell, and even chirp within.

The eggs intended for an incubator should be fresh, not more than seven or eight days old, ten being quite a limit; very large, very small, or badly-shaped eggs should be rejected, while hens' eggs are preferable to those laid by pullets.

Foster-mothers and all other necessaries should be well examined and cleaned, plenty of fresh sand being used for the floors and runs, of which we give examples in **62** and **64**.

Some Results of Scientific Observations. There is very little data existing upon which absolute reliance can be placed as the work of scientific observation. Brief reference, however, may be made to the demonstrations by Mr. Edward Brown, F.L.S., the lecturer who is in charge of the poultry farm of the University College, Reading. Mr. Brown worked six incubators, all of different types, for twelve months, in a specially constructed house, where the conditions as to equability of temperature and ventilation were specially favourable. The machines employed were both of the tank and the hot air types, and during the twelve months referred to there were 89 hatchings, 7,790 eggs having been placed in the machine, of which 6,330, or 81 per cent., were fertile. The number of birds, chickens, and ducklings hatched was 4,631, or 73 per cent. It was found that fertility was lowest in February and highest in November, whereas the hatching results were highest in September, and lowest in August. The variation in the percentage of fertile eggs hatched from month to month was considerable. In August the figure reached 64 per cent., in September 83 per cent., while as regards the hatching of fertile eggs in the various machines, the highest, 94½ per cent., was in a tank machine, and the lowest, 34¾ per cent., in a machine of a similar type. It is indisputable that while in eight months of the year the highest results were obtained from the tank machines, the hot air machines took the leading position during the remaining four months. There is apparently little difference in the results where machines of various sizes are compared, for while a small machine of 50-egg capacity gave a percentage of 79½ fertile eggs hatched, a 360-egg machine gave 76½. In


INCUBATOR RECORD

NAME OF INCUBATOR .... EGG CAPACITY
NUMBER OF INCUBATOR .... NO HATCHED
DATE SET .... 190 DATE OF HATCHING 190
EGGS FROM PEN NO .... BREED ....
NUMBER OF EGGS SET | NUMBER FERTILE 1ST TEST | PERCENTAGE FERTILE | NO. LIVING 2ND TEST | PERCENTAGE LIVING | NUMBER OF CHICKS | PERCENTAGE OF TOTAL EGGS SET | PERCENTAGE OF LIVING GERMS | NO CHICKS ALIVE AT 2 WEEKS OLD
TOTALS
DAY | TEMPERATURE OF ROOM A.M. P.M. | VENTILATOR | TEMPERATURE OF INCUBATOR A.M. TO P.M. | REMARKS
1 | 65 | 60
2 | 55 | 53
3 | 49 | 47
4 FIRST COOLING | 45 | 44
5 | 48 | 51
6 | 54 | 57
7 | 60 | 62
8
9 TEST
10 AVERAGE TEMPERATURE OF INCUBATOR TO DATE
11
12
13 TEST
14
15
16
17 LAST COOLING
18 CLOSE AVERAGE TEMPERATURE 11TH TO 18TH DAY
19
20
21
AVERAGES RELATIVE HUMIDITY
WAS MOISTURE USED? .... WHEN? ....
HOW? ....
DESCRIPTION OF INCUBATOR ROOM ....

neither case, however, were so many eggs submitted to test as in machines of medium capacity, the largest number being placed in 100-egg and 120-egg incubators, and in these the hatchings reached 71 per cent.

The figures in the table, which are a summary of results obtained from incubators at the College Farm, will afford most valuable information to those who propose to adopt artificial incubation.

The incubator worker is advised to keep a record, and we have, with slight alteration, supplied an example form which has recently been published in the "American Agriculturist."

Continued

SAXOPHONES & TROMBONES

Construction of the Instruments. Open and Closed Notes. Position. Scales and Exercises. The Cost

Continued from page 5140

By PAUL CORDER and ALGERNON ROSE

THE SAXOPHONE

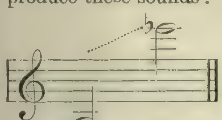
The saxophones, called after their inventor, Adolphe Sax, form a group of instruments resembling in some respects the clarionet; but their tone is more powerful and better suited to the open air. They also differ materially in construction. They are chiefly used in military bands, but have lately found their way into the concert orchestra, and when well played are capable of producing a fine tone.

Saxophones are made in six sizes, of varying compass:

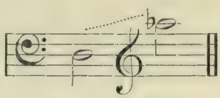
The sopranino saxophone in E♭, soprano saxophone in B♭, alto saxophone in E♭, tenor saxophone in B♭, baritone saxophone in E♭, bass saxophone in B♭. The first and last are but seldom met with. There is also a similar series of six made in F and C, a tone higher than the corresponding instruments in E♭ and B♭, but they do not appear to be much in use.

In order to facilitate matters for the performer, and to enable him to play on any of these instruments without the necessity for learning twelve different fingerings, a uniform notation has been adopted for all sizes of saxophone. This assumes the compass of each instrument to be irrespective of the real sounds,

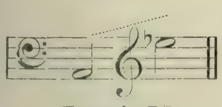
whereas those shown above are the actual notes produced only on the soprano saxophone in C. For the four instruments chiefly used, the notes below will produce these sounds:



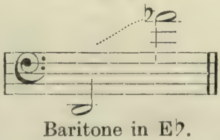
Soprano in B♭.



Alto in E♭.



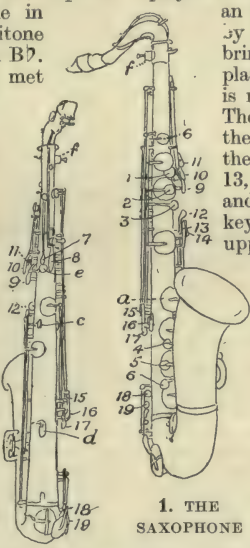
Tenor in B♭.



Baritone in E♭.

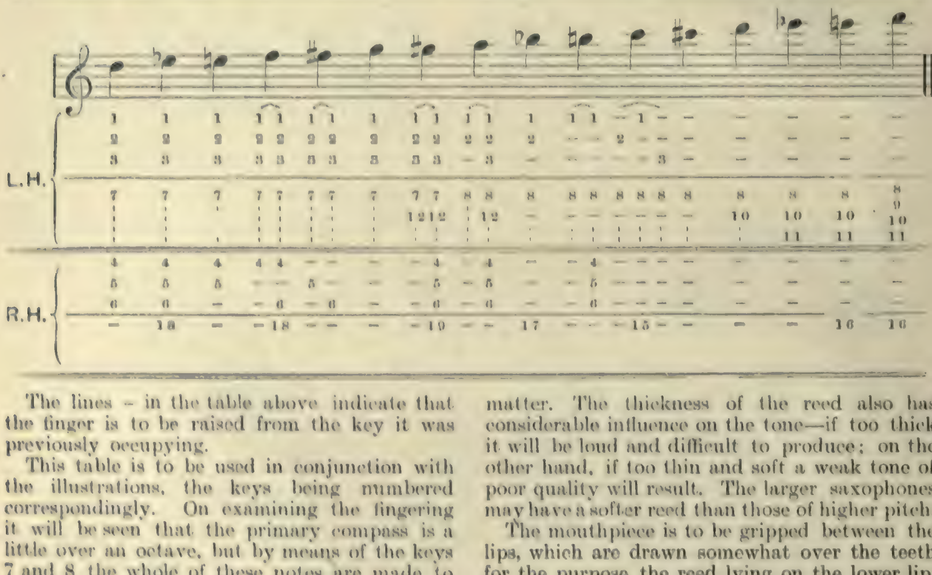
This statement is not strictly correct, for, as will be explained later, the two highest notes can only be obtained on the contralto and tenor saxophones.

The shape of the saxophone will be seen from the illustrations, which represent a B♭ tenor instrument. It consists of a conical metal tube with about 20 lateral holes, which are covered and uncovered by means of a series of levers and finger-plates. The mouthpiece is similar to that of a clarionet, a single reed being employed. With the larger saxophones the weight is partly supported by means of a strap, which is passed round the neck of the player and hooked on to the instrument through an eye [1*c*]. The hook, *d*, is occupied by the thumb of the right hand, which brings the three principal fingers over the plates marked 4, 5, 6. The little finger is ready to depress the levers 18, 19. The left hand clasps the instrument with the three longer fingers on plates 1, 2, 3, the little finger controlling the levers 12, 13, 14. The thumb rests on the plates, and works the octave keys 7, 8. The keys 10, 11 are manipulated by the upper joint of the forefinger and 9 by the middle finger. Levers 15, 16, 17 are correspondingly managed by the upper joint of the right forefinger. The only two keys not accounted for are those marked *a* and *b*. These cannot be operated separately, but work in conjunction with any of the finger-plates of the right and left hand respectively. The fingers must never be held quite straight, but should all be curved slightly, a position which tends to promote agility in passages. The clamp, *f*, is intended to hold a little music-clip for use out of doors. In the table of fingering which follows it will be noticed that many notes can be played in more than one way; to determine which should be adopted will depend entirely on the music, one fingering being more suitable to some particular passage than to others. This matter the student can learn only by experience.



1. THE SAXOPHONE

In the table on the next page the figures 1 to 6, above the line in each hand, represent the keys controlled by the first three fingers of either hand; the figures below the line refer to the extra keys, all of which are numbered as in the illustrations. 7 and 8 are played with the left thumb, 9 by the middle finger, and 10 and 11 by the upper joint of the forefinger, 12, 13, 14, by the little finger. The right hand manages 15, 16, 17 with the upper joint of the forefinger, and 18, 19 with the little finger.



The lines – in the table above indicate that the finger is to be raised from the key it was previously occupying.

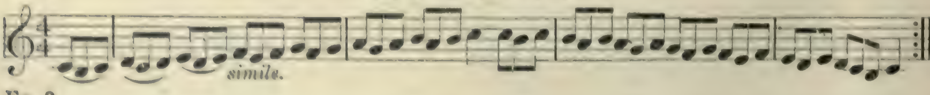
This table is to be used in conjunction with the illustrations, the keys being numbered correspondingly. On examining the fingering it will be seen that the primary compass is a little over an octave, but by means of the keys 7 and 8 the whole of these notes are made to sound an octave higher; and the compass is completed by means of extra keys for the last four notes. The top E and F can only be obtained on the alto and tenor instruments, and, with some makers, on the baritone.

The Reed. The proper management of the reed may give some trouble at first, as the quality of the tone depends mainly on this important matter. The thickness of the reed also has considerable influence on the tone—if too thick it will be loud and difficult to produce; on the other hand, if too thin and soft a weak tone of poor quality will result. The larger saxophones may have a softer reed than those of higher pitch.

The mouthpiece is to be gripped between the lips, which are drawn somewhat over the teeth for the purpose, the reed lying on the lower lip, with about a third of its length in the mouth. The pressure of the lips will vary with the pitch of the note. The tip of the tongue at the end of the reed serves to give an "attack" to notes requiring it. This is called *tonguing*.

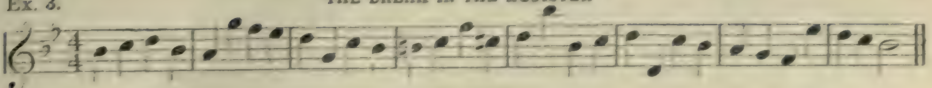
The student should begin with a few simple exercises in sustained notes, endeavouring to obtain an even tone throughout, both in *forte*

Ex. 1. THE LOWER REGISTER



Ex. 2.

Ex. 3. THE BREAK IN THE REGISTER



Ex. 4. ARPEGGIOS

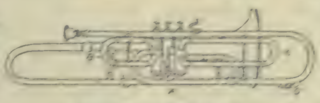
and *piano.* These may be followed by scales and simple passages, played at first slowly and afterwards more rapidly. Slurring two or more notes together and detached notes and simple tonguing exercises may follow. As soon as familiarity is acquired with the fingering the scales should be studied in every major and minor key, as well as the chromatic scale. A few easy exercises are given here, and the student may construct others for himself on the same plan.

TROMBONES

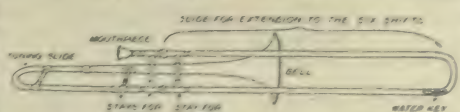
Trombones are of two kinds, those with slides and those with valves. The latter, on account of ease in learning and fingering, are extensively used to supplement saxhorns in brass bands.

Valve Trombones. The mechanism of the pistons is the same as that for the baritone saxhorn; the method of tuning being also alike. As band parts are written in the treble clef, the student will find the instructions given concerning the saxhorns applicable to the valve trombone [page 5130]. The valve trombones are strongly made for Army use, in four patterns, the alto in E♭, costing from about £3 10s.; the tenor in B♭, from about £4 4s.; and the bass in G, from about £6; whilst some firms manufacture a special contra-bass in E♭, costing approximately £11. Mouthpieces range in price from 4s. to 7s., whether plated or silver-rimmed; and black or brown leather cases are to be had from £1 upwards.

In Germany, Austria, and other parts of the Continent, brass wind instruments, instead of having pistons, are furnished with rotary-action keys. The touch, it is claimed, is thereby more delicate, and the intonation more accurate. For parade purposes, nevertheless, such mechanism gets out of order sooner, and is more difficult to make right, whereas a piston can be quickly unscrewed, cleaned, and readjusted. Holding the instrument firmly with the left hand, leave the right free, as in the saxhorn, for manipulation of the valves. In the tenor valve trombone, the first note to sound is B♭, second line bass clef, this being the easiest to produce. Avoid attempting to get the upper sounds until the lip has been exercised by scales in the lower register. Practise at first frequently, at short intervals. This will prevent the lip from becoming tired, and ensure more progress than longer study. It is when fatigued that bad habits are usually contracted, and, once acquired, they are difficult to break. Some students, by persisting in trying to run up the high notes of a scale before walking slowly among the low sounds, have spoiled their lips for good playing. If the student does not begin with the low notes and gain power over them gradually, the danger is that too tight a pressure from the mouthpiece at first may partially paralyse the lip-muscles. The main difference in the valve trombone compared with the baritone saxhorn—the fingering is the same—is the ringing sound which the straighter tubing, arranged horizontally, imparts. Unless proportions are exact in internal diameter from mouthpiece to bell, and the brass is of good quality and medium thickness, clearness will be lacking, and the open notes will be neither firm nor satisfactory in timbre.



VALVE TROMBONE
a, b, c. Tuning slides. *d.* Water key



SLIDE TROMBONE (Metzler & Co.)

Slide Trombones. The ambitious student, however, will not content himself with the piston mechanism. If he has an opportunity of becoming possessed of a slide trombone, he will soon perceive that for purity and brilliancy of tone it is far preferable to the instrument with valves. Indeed, the slide trombone takes very high rank in the modern orchestra. Although one of the most ancient, it is the most perfect of all wind instruments, and is therefore recognised as the King of the Brass. There is no grander tone than that of a well-played trombone, for it sounds an impressive fortissimo without vulgarity, and the most whispering pianissimo with wondrous clearness. The beautiful qualities of the slide trombone are heard to advantage—as is the case with stringed instruments—in a quartet of accomplished players.

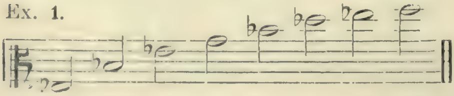
The Trombone Quartet. Formerly, there was a soprano trombone in B♭, playing an octave higher than the tenor instrument. It is still occasionally employed for the interpretation of parts in certain compositions by Bach and Mozart, being used to double or sustain the soprano voices. But, as it is scarcely ever met with in England or France, we confine our attention to the other three members of the family. Of these, the tenor has the best quality of tone throughout the extent of its scale. It is, therefore, given first and second parts; but to make up the trombone quartet the alto and bass

instruments are indispensable. These are all alike in pattern, differing only in length of tube, which is divided into two U-shaped parts of cylindrical bore. The first part expands outwards at the bell, and from the portion of the tube opposite the bell projects a brass stay, to which is affixed the mouth-tube, furnishing the cup for the player's lips. The second U-shaped tube is the trombone slide. This telescopes over the two ends of the first U-tube. At the lower end of the slide is the water-key, and at its upper end is the stay, extended by the right hand of the player for the various "shifts." In the bass trombone this stay has a hinged handle, to enable the performer to get the lowest notes. Thus, by pushing out the slide, the air-column can be lengthened with ease, so that, in the E♭ alto, notes in the 6 in. or 4 ft. octaves can be sounded by a simple movement. Likewise, in the tenor and bass instruments, the 2 ft. can alternate with 8 ft. sounds at will.

It is because no fixed points, such as piston-buttons, keys, or frets, regulate the pitch for different sounds, that—as is the case with the violin or the voice—the trombonist must be guided by the musical qualities of his ear. Every shift transposes the instrument a semitone lower in pitch. But if quarter tones are required they can be obtained. As these, and even eighths of tones, are employed in certain Oriental melodies, the only European instruments capable of performing them are our violins and trombones. On all piston instruments, as with the piano and church organ, there is no sensible difference between A♯ and B♭, D♯ and E♭, and so on. On the slide trombone, however, accomplished players give the true enharmonic sounds by moving the slide a little higher up for sharpened notes than they do for those which are flattened.

Compass. The trombones are not "transposing" instruments, but sound the notes as written. Each model has a compass of a little over two octaves, but an octave and a half suffices for the best effects. For the alto trombone in E♭, the music is written in the alto clef, with C on the third line. In this instrument the student should cultivate the higher rather than the lower sounds, as the latter are better played by the tenor instrument. The quality of tone of B (first ledger line above alto staff), C, D, E, and F, is particularly useful. When the slide is closed, the notes in Ex. 1 are obtained

Ex. 1.



by the lip, without counting the fundamental C♭, which is unsatisfactory.

By means of changing the position of the slide, the tone extends from A (below second ledger line) to D♯ (on second ledger line above staff), with all the intervening semitones. The cost of the alto in E♭ ranges from £3.

Tenor Trombone. The tenor, the chief instrument of the family, is in B♭. Music for it is written both in the tenor and the bass clef, so the student is advised to accustom himself equally to both clefs, by writing out exercises printed in the bass with the tenor signature, and vice-versâ. The lowest note on the tenor trombone is E, first ledger line below bass staff, and the highest is A♮, over third ledger line above staff. In England the price ranges from about £3 5s. for a well-made instrument. When three tenors are used together, it frequently happens that the music is written in three clefs, alto, tenor, and bass, the first having C on the third line, the second C on the fourth, and the third F on the fifth. This makes the parts easier to read than when many ledger lines are used, as soon as the student has accustomed himself to the clefs. If habituated to the treble clef, he has only to imagine in the alto that every B becomes a C, every C a D, and so on, an octave lower. This operation is reversed for the tenor clef, with middle C on the fourth line. Then every C becomes a B, every D a C, and so on, an octave lower than it would be in the treble clef. By transposing on paper melodies written on one clef into another, the trombone student will soon acquire the necessary knack, so that when he takes his place in an orchestra he will have an advantage over players, perhaps more proficient than himself, who have not given attention to this matter.

The Importance of the Slide. The superiority of the slide over valves will be evident if we compare two instruments, by taking two tubes of equal length, one straight—such as the coach-horn—and the other of the same length coiled up like a bugle. The tone quality of the straight instrument is more ringing, and carries a greater distance. Inevitably, in piston instruments, the extra tubing attached to different valves, when not used, is so much dead weight, impairing the vibration. Moreover, on account of the differing length of the air-column within the tube, if the second piston lowers the sound half a tone, and the third a tone and a half, the additional tubing for the half-tone of the shorter air-column may be true when transposing the pitch of open notes. But its length will be obviously insufficient when added to the tone

Ex. 2.

Ex. 3.

and a half of the longer column opened up by the third piston.

The harmonic series on valve instruments thus sounds too sharp when more than one piston is used. To compensate for the discrepancy a fourth piston is sometimes added in the larger valve instruments ; but in the slide trombone, as on the violin, the player regulates the length of each vibrating segment at will, so that he is able to produce truly almost every harmonic he desires. The slide trombone, and particularly the tenor, is thus more perfect, musically, than any other wind instrument.

First and Second Positions. When the slide is closed the trombone is said to be in the *first position.* In a tenor instrument, as with the open notes on a baritone saxhorn, the following five harmonic sounds result: B♭ (second line bass clef), F, B♭, D, and F above. Later on, when the lip of the student obtains these notes with facility, with a tighter embouchûre, he will get the A♭ and top B♭. At first, however, the lip should never be forced unduly.

Having mastered these sounds, beginning with the B♭, and not resting satisfied till the F above is produced clearly, as well as the octave B♭ and the tenth, with increased tension for the higher notes, the lip may be exercised by changing the order of the sounds. At first it is well to give a separate breath to each note. Play in slow time, counting four on every one sound. Then shorten the duration of each note by counting, mentally, two for every one ; and, finally, get the five notes clearly on the five beats. After transposing the order, triplets and dotted notes may be practised in slow time. Do not attempt double or triple tonguing, nor waste time exercising to get a trill by moving the slide in and out. [Ex. 2].

In different makes of instruments the distance to which the slide should be extended slightly varies for the different positions. Generally speaking, what is known as the "first shift" (analogous to putting down the second piston on the baritone saxhorn) is three and a half inches, or 70 millimetres from the first position when the slide is closed up. This gives the second position.

Attitude. A word here may be said regarding the attitude of the student. His head and body should be erect. The instrument must be grasped firmly without unnecessary movement, keeping the left arm to the side. Although in some instruments the elbows may be kept close to the body, there should be no pressure on the ribs in trombone playing, or breathing will be impeded. The thumb and middle finger of the left hand hold the cross-stay nearest the player, whilst the first left finger hooks itself over the second stay, so as to regulate the pressure of the mouthpiece on the lips. The other two fingers should be bent over gracefully. As regards the right hand, the thumb and forefinger hold the stay crossing the near end of the trombone slide, the fingers being closed and not opened.

When in position the main tube, which carries the bell, passes over the left shoulder, and the slide should be held slightly downwards, as remote positions are then easier to obtain accurately and the strain is less on the upper lip. At the bend of the tube over the left shoulder is the tuning slide, which should be kept in good order. If the pitch of the instrument is too sharp, it can be corrected by slightly pulling out this part. As regards choice of mouthpiece, the student is referred to the remarks made on that subject in the Saxhorns [page 5131–2], as also for the method of blowing. The tongue, however, must not give any stroke before the slide is extended or contracted to the position required to produce the note to be played. It is only by constant practice that the forearm and wrist will move with the necessary suppleness and stop without hesitation at the exact point required. Military trombone players are apt to cultivate a hard, brassy tone, which becomes disagreeable in the concert-room. Having sounded, with the slide closed, the B♭, F, B♭, D, and F above (articulating the syllable "too" by a movement of the tongue as if expelling a bit of fluff from the mouth), by extending the slide to the first shift the harmonic series will be found lowered a semitone in pitch. The low note, therefore, should now be A♮. Get this clearly. Then sound the E above. Next obtain the octave A ; afterwards the tenth, or C♯ ; and, finally, the twelfth, or E. The tone is thus transposed from B♭, with two flats, to the key of A, with three sharps.

As before, having obtained the five sounds distinctly, change their order, practising the fifth with the keynote, the twelfth, octave, tenth, and so on, varying the rhythm and increasing the speed as the lip gains in flexibility [Ex. 3].

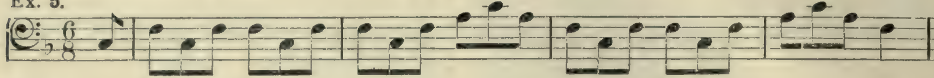
Third Position. By extending the slide about seven inches from the first position, the student gets to the "second shift," analogous to putting down the first piston of the baritone saxhorn. The instrument, therefore, giving as its low note A♭, has now transposed itself from a sharp to a flat key, with four lowering signs—B, E, A, D. The first note to sound is therefore A♭, first space bass clef. Above it comes the fifth octave, tenth, and twelfth from the tonic, or E♭, A♭, C and E♭. Blow these sounds carefully without forcing them, practising the three lower ones before attempting the two higher. Construct exercises on these five notes.

Fourth and Fifth Positions. Extending the slide about 10½ in., the student reaches the "third shift," giving the same sounds as when the first and second pistons in the baritone are put down. The low note is now G♮. So the fourth position brings us into an easy key so far as concerns the reading of notation. Get this low G (first line bass clef) with a full, mellow tone, and then the fifth, octave, tenth, and twelfth above, or D, G, B, and D. In learning the harmonic series on the different positions, the student will find assistance by transposing the different Army bugle-calls into the various keys of the positions. Try the Sergeants' Barrack Call [Ex. 4].

The fifth position is otherwise known as the "fourth shift," and gives the same sounds as when the second and third pistons are put

Ex. 4.

Ex. 5.



Ex. 6.

down together on the baritone. Extending the slide 14 in., the low note will now be G♭, or F♯, so that there is a choice of a key with either six flats or six sharps. Sound low G♭, with D♭, B♭, and D♭ above, practising especially the three lower notes till they are sounded with facility.

Sixth and Seventh Positions. Pushing out the slide 17½ in. gives us a fifth shift, with sounds similar in pitch to those of the baritone when the first and third valves are put down. The harmonic series is now in the key of F—a favourite in military music, with one flat, B. Sound low F, with C, F, A, and C above. Try the "Sergeants' Dinner Call" [Ex. 5].

Extending the slide 21 in., we get the "sixth shift," or extreme position, as when all three pistons are down on the baritone. This lowers the sounds from F to E♮, so that the key has now four sharps instead of one flat, the low note being E, first ledger line below bass staff, and not E♭, as is sometimes written by composers. Sound the low E, with B, E, G♯, and B above, practising, with the first, the intervals of a fifth, octave, tenth, and twelfth. As an exercise, we give the opening bars of the "Last Post" [Ex. 6]. For a shilling, the student can get all the Army bugle sounds. If he does this, he will observe that, as the calls are written in the treble clef in C, for this position he has merely to obliterate that clef and add four sharps, and the notation is precisely the same for the bass. For the sixth shift, he thus has plenty of exercises admirably adapted for familiarising him with the correct sounds and articulation of the five notes.

Inserting Thirds. Knowing that this is a chromatic instrument, the student, noticing the skips in each series from the keynote to the fifth, from the fifth to the octave, and thence to the tenth and twelfth above, will be eager to understand how the missing sounds are filled up. If he endeavours prematurely to attack the chromatic scale his mind will become confused. He must be content, therefore, not to rush at the problem, but to master the instrument gradually. That interval most required is the third. If he inserts this neatly in each series, meanwhile, he will be going in the right direction. Having closed the slide and returned to the first position, a third above B♭ is D. This, it will be remembered, is the second note in the fourth position, or third shift, or a fifth above G. Sound the B♭. Then advance the slide 10½ in., so that the D is given clearly. Play these two notes slowly in succession and gradually quicken the pace. Sound the low B♭, following it by D, in the third shift; return to the first position, sounding F, B♭, and D above, the second D being in the first position. Then descend the series in like manner, extending the slide accurately for the lower D. In the same way, the missing third in the second position will be sounded by extending the slide to the fifth position; that lacking from the third position by expanding the tube to the sixth; that absent from the fourth position will be obtained from the seventh; that missing from the fifth will be found in the first; the third absent from the sixth sounds on returning to the second; and the third which cannot be produced in the seventh is elicited on coming to the third.

When once the mind of the student grasps the idea of the principle governing the manipulation of the slide for the insertion of the thirds, he has practically filled up the whole diatonic series of notes for the performance of all the major scales. But he must work first on the thirds, constructing exercises to familiarise himself with the most usual shifts. A little thought will enable him to do this. If ingenuity lacks, many cheap instruction books may be obtained. These, however, usually give the exercises without the explanation which a master is supposed to supply. Nevertheless, the best teachers have been the readiest to recognise the importance of self-culture and of stimulating the student to acquire knowledge by the active exercise of his own faculties. Mere passive perception of details of knowledge may answer average requirements, but the best master in the world cannot make a good musician if the student shrinks from using his intelligence.

Scale of B♭. Get the low B♭ in the first position. Use the sixth for C♮, this being the second harmonic in that series. Now slide to the fourth position for the D, and the third for the E♭. F♮ is obtained in the first position. So far, except the first, the notes have all been second of their harmonic series. With somewhat more tension on the lip, get the G on putting the slide in the fourth position and sounding the third harmonic of that series. Then get to the second position for the A, produced equally on the sixth, but with a tighter lip. For the B♭, return to the first position or go from the sixth to the fifth. C is sounded in the third or the sixth position. B♭ is obtained in the first or fourth. E♭ is the fifth sound in the third position or the sixth in the sixth position.

Finally, F ♮ above is the fifth sound in the first position, the seventh in the sixth, or the sixth in the fourth. Return in the same way, and when low B ♭ is reached, the A beneath it can be obtained in the second position, the G in the fourth, and the F in the sixth. Then return to the B ♭ to complete the scale.

C Major. The first note, second space bass clef, or first space below tenor staff, is obtained from the sixth position. D above is the second sound in the fourth position. E ♮ is obtained in the second position and F in the first. G is the third sound in the fourth position, A the third in the second, B ♮ the fourth in the fourth position, C the fourth in the third, D the fourth in the first, E the fifth in the second, F the fifth in the first, and G the sixth in the fourth. This is as high as the student should attempt. Return in the same way.

The Relative Minor. Write out the foregoing exercise both in the bass and tenor clef, putting the numbers of the positions over each note. If we now take A minor, the low sound in the second position gives the first note. Extend the slide to the seventh position for the B, which is the second sound in that series. Then bring the slide to the sixth position for the C above, to the fourth for the D, and the second for the E. For F ♯, extend the slide to the fifth, that being the third note of the series, and bring the slide to the third position for the G ♯. Draw it to the second position for A ♮, and extend it to the fourth for the B. The third position will then give the C, the first the D, and the second the E. That is the limit. Returning, sound the top E, D, C, B, and A as before. Now G ♮ will be the third note of the series in the fourth position, instead of G ♯ in the third, while F ♮ is the second sound in the first position instead of the third in the fifth, which gave F ♯. Get the E, D, C, B, and A as before.

The instructions given for cleaning saxhorns apply equally to the trombone, but the simplicity of this instrument renders it much more easy to keep in order. The water-key should be used to let out the moisture condensed with the breath at intervals during playing. On conclusion of practice the slide tube should be detached and inverted. Unlike the violinist, the trombone student has no strings to adjust, nor has he, like the clarionet, oboe, or bassoon player, any reeds to trouble him, nor keys to clean.

BASS TROMBONE

This instrument extends the compass of the tenor four semitones downwards to C ♯, second ledger line below bass clef. Its great value is that, in sustaining chords, the slide instrument is distinguished by remarkable depth of power and sonorousness impossible to obtain from the smaller members of the same family. As the tube is longer and the instrument heavier, the student who takes up the bass trombone ought to be strong-chested and strong-lipped. The manner of holding the bass trombone is similar in method to the attitude described for the tenor ; but for extreme positions the right hand manipulates the handle, which is hinged to the stay at the top of the slide. Be careful, on account of the weight of the instrument, that the grasp of the left fingers on the other stays is firm, so that the mouthpiece may not be jerked from the lips, and the embouchûre upset, by undue thrusting forward of the slide by the right hand.

The Seven Positions. As in the tenor or alto so in the bass trombone, there are seven positions or six shifts. In the G trombone the instrument is in the first position when the slide is closed, analogous, in an instrument with pistons, to the open notes of the latter which sound when no valves are used, with this result : G (first line bass clef), D (third line), with G, B, D, F, and G above. On the long tube, therefore, seven harmonics, the last giving the double octave from the low G, can be produced by tightening the lips after a fair amount of practice.

On a G valve trombone the pitch is flattened a semitone, throughout the harmonic series, by pressing down the second piston ; or when the slide is moved forward 4½ in. the result is the same, as we then have the last-mentioned notes preceded by flats. This gives the second position. Write out each position on paper.

On a piston bass trombone, the open pitch is flattened (for the third position) a whole tone by pressing down the first valve. On a slide instrument, move the stay about 9 in. from the first position. The harmonics then obtained are F (below bass staff), with C, F, A, C, E ♭, and F above.

By pressing down together the first and second pistons, or the third alone, a G valve trombone is flattened a tone and a half. On a slide instrument, extend the stay about 13½ in. The resultant tones are then E (first ledger line below staff), with B, E, G ♯, B, D, and C above—the fourth position.

Fifth Position. Depress the third and second pistons together. This flattens the G valve trombone two whole tones—the fifth position. Extend the slide—on an instrument without valves—about 17½ in. The harmonics then obtained are similar to those of the last position preceded by flat signs.

Putting down first and third pistons together, the pitch of a valve instrument is lowered two tones and a half—the sixth position. Without valves the slide must be extended 21¾ in., the harmonic series elicited being D (below first ledger line), A (a fifth above), D (an octave above), F ♯ (a fifth above), A (a twelfth), C (a fourteenth), and D (a fifteenth from the tonic D). Thus it will be observed how in cylindrical tubing the harmonics sound closer together as the pitch ascends and each vibrating segment diminishes in length.

To get the instrument in the seventh position, simultaneously depress the three pistons. This flattens the instrument three whole tones, thus: One tone by the first valve, a tone and a half by addition of the second, and another tone and a half with the third down, or three together. This effect, however, is produced more truly on

Ex 1.

a slide instrument by extending the stay, with the handle, a distance of 26 in. This is 5 in. more than was necessary on the tenor. The notes last mentioned are now flattened a semitone, so that the lowest sound, D♭, gives the enharmonic C♯, or bottom limit to the compass of the trombone family. In actual playing, except for its two pedal notes, this position is seldom employed.

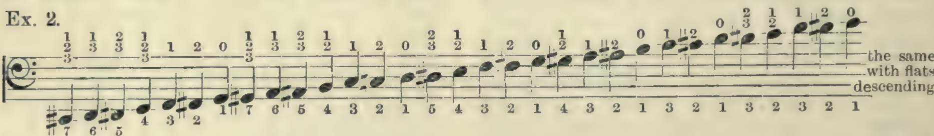
Diatonic Scale. Having begun with the pistons up, or the slide closed, and obtained clearly the harmonics in the first position, then, having practised the shifts without tiring the lip with the upper notes—especially in the fourth, fifth, sixth, and seventh positions—the student must endeavour to master the scale of B♭ major. We give it with the fingering above the staff for the G valve trombone, and with the positions marked underneath for the slide instrument [Ex. 1].

Intervals. The manner of inserting thirds in the tenor slide trombone equally applies to the bass instrument. In addition to thirds, the student, however, should familiarise himself with other intervals. At first, every such exercise should be practised slowly. If the scale of B♭ major is taken, B♭ (second line, bass clef), as we have seen, will be sounded in the fifth position. Return to the first position to obtain the D, a third above. C (second space) is easily sounded by the slide resting midway in the second position. In exercising the lip, get, therefore, the intervals of seconds and thirds in succession by playing clearly and softly B♭, C, D, and B♭. Before proceeding to treat the second degree of the scale in the same way, take a fresh breath. Sound C, as before. Get the third above (E♭) by putting the slide in the fifth position. Connect the two intervals by the D, with the slide close up, and return to the C. Again pause.

Proceed to the third degree. Sound the D as before. F (a third above) is obtained by the third position. To insert the E♭ between these notes, extend the slide to the fifth position. Then return to the D. Take a fresh breath and start again on the E♭. Get the G, a third above, by bringing the slide to the first position. Insert the F, and return to the E♭. Next, try the F (third position), following it by the A above (also in the third), but insert the G by closing the slide in the first position. Take a short rest before striking, with a firmer lip, the G on the fifth space. Get the B♭, a third above, by extending the slide to the second position, and insert the A by going to the third. There is no need for the beginner to proceed beyond the B♭. Intervals of fourths, fifths, sixths, sevenths, and octaves should be treated in similar fashion.

Chromatic Scale. Transpose the scale above on paper into the other major scales. Mark the fingering of each note, or the position, by referring to the particulars already given. But, in order that the student may be able to play correctly the keys containing sharps or flats not yet mentioned, as well as minor scales, we give the fingering for the valves, and positions of the slide, for the chromatic scale throughout the entire compass, using sharps in ascending and flats in descending [Ex. 2].

Ex. 2.



Amongst the great composers who have given most prominence to this wonderful family of instruments may be mentioned Wagner, Strauss, Gluck, Beethoven, Rossini, and Mozart.

The Cost. According to the quality and the particular make, so the price of a G trombone varies, but a good bass instrument may be obtained from £3 10s. upwards. On account of the extra mechanism, a valve instrument costs from £5 upwards. Mouthpieces and cases are similar to those for the tenor.

SAXOPHONES *and* TROMBONES *concluded*

WHERE TO LIVE & BE HEALTHY

Effect of Climate and Soil on Health. Surface Soil and its Bacteria. The Hygiene of Soils. Good and Bad Sites for Houses

Continued from page 5196

By Dr. A. T. SCHOFIELD

THE cooling of the molten part of the earth's surface produced the igneous rocks, while the rain and decomposition due to weather produced the sedimentary rocks and soils. Among the igneous rocks we may include lava, basalt, granite, etc. Among sedimentary—or aqueous, as they are rightly called—we may include sandstones, greensand, limestone, chalk, gravel, clay, and the soil itself, as surface or subsoil.

What a Pound of Earth Contains. Surface soil is largely an organic composed of decaying vegetable and animal matter. The subsoil is composed of inorganic debris of rocks only. Soils are constantly moved up and aerated (like currents of air) by the labours of earthworms, moles, ants, etc.

The surface soil is so full of bacteria that it is calculated there are some 500,000,000 in every pound of earth. These have the power readily to decompose organic matter into nitrates, nitrites, ammonia, carbonic acid and water.

Vegetables, unlike men, cannot assimilate nitrogen from complex bodies, but only when these are split up.

Certain vegetables (legumes and cereals) can get their free nitrogen, without ammonia or nitrafication, by means of bacteria that form nodules and colonies in their rootlets, and supply it to their hosts. They have to be fed with a carbohydrate, and fix the nitrogen in proportion as they use up the former. *Nitragen*, as these microbes are called, is sold for fertilising grain and bean crops. No less than seventeen different solutions of germs for seventeen varieties of crops are made and sold at 2s. 6d. per bottle, two bottles fertilising an acre, and enormously increasing the yield. Earth entirely freed from bacteria is sterile and will not nourish plants.

The pathogenic or disease-bearing bacteria common in the soil are those of tetanus or lockjaw (very common in garden mould), typhoid, glanders, anthrax, and cholera. The surface soil is thus a great laboratory for germs and worms.

The Effect of Soils on Health. Clay produces rheumatism, catarrhs, neuralgia; alluvial soil, malaria; gravel and chalk are excellent for health. Old Swindon is on limestone and sand, and New Swindon on heavy clay. The cases of measles in New Swindon are 20 to 1 compared with the other town, and chest diseases are one-third more. The looser the soil the higher the temperature, and the frost does not strike so deep.

Air in the soil varies according to the soil In sands it may be as much as 50 per cent. It generally resembles the air above, but, inasmuch as the composition of the air is variable, being a mixture and not a compound, it is not exactly the same. It is always more impure, the oxygen is less and the carbon dioxide is more with the increasing depth of the soil from the surface. The proportion of nitrogen remains constantly in the same proportion as in the atmosphere. The excess of impurities and carbon dioxide in the ground air is so great that it is dangerous to let it enter the house, as it does at times. The carbon dioxide always increases after rain.

Ground air moves by temperature, pressure, rain, and subsoil water. After heavy rain it may be forced out in dry places, such as basements, and so enter the house. Besides this, dwellings are warm, and thus suck the ground air in. Gas has been known to be drawn into a house from a burst pipe 20 ft. distant through the soil.

Water in the Soil. The moisture in the earth at certain depths, increasing to saturation, forms a continuous sheet of water at from a few inches to 100 ft. below the surface. Above this level the soil is kept moist by rain; below this level by capillary attraction and the evaporation of the water below.

Subsoil water is always slowly moving towards some outlet. Rising subsoil water is dangerous, as it forces the air out of the soil and leads to the possible pollution of shallow wells by connecting them with neighbouring cesspools. Falling subsoil water leaves the soil moist and full of air.

All soils hold water in proportion to their permeability and absorption. Their permeability is the speed of percolation through them; clay is the slowest; chalk, greensand, and sand, the quickest. Below is a table of the absorption of water in soils.

	Per cent.		Per cent.
Granite	·1 to ·4	Sandstone ..	3 to 8
Slates	2 ,, 10	Chalk	15 ,, 20
Limestone ..	5 ,, 10	Marl and loam ..	30 ,, 50

Moisture in soil increases with the amount of organic matter. If the subsoil water be within 5 ft. of the surface it is injurious to health.

In summer there is little percolation. The ground water begins to rise in November, and reaches its maximum about March, decreasing towards the summer.

A permanent level of subsoil water is much better than one that fluctuates; and a low level is best. The level of subsoil water can be tested by cups fixed in a rope in the well. Uniform depth of water in a well shows the level of subsoil water. The rise and fall of the water was discovered by Pettenkoffer to be the cause of typhoid in Munich.

To lessen and carry it off there require to be large, porous drainage pipes laid 3 ft. below the surface and 6 ft. apart—quite distinct from all drainage. Damp soil signifies air and water; ground water means all water and no air.

Loose sand holds 2 gallons of water per cubic ft. Sandstone holds 1 gall. The subsoil

water in Austria moves up and down with the Danube, though it is three-quarters of a mile away.

Sites for Houses. A good site requires pure air, no dust, level ground, sunshine, an even temperature, and no strong winds, and should be away from motor-haunted highways or byways. Valleys should be avoided and depression and pockets on levels. A slight elevation is good—on the spur of a hill or terrace. Houses should not be built under the side of a hill. The soil and subsoil should be examined; there should be no gravel pockets on clay, which are always very damp. Clay with sandstone is good. Peat and organic refuse, "made" and alluvial soils are bad. Sandstone and gravel is often damp—limestone is best. Soil made up of "shot" rubbish should never be used.

The side of a hill is, of course, warmer than the valley, because while the warm air rises the cold slides down the hill. In a valley the fogs lie and the frosts are always keen. There should always be shelter from the prevailing wind of the district.

There should be free circulation of air, sheltered from the north and east by rise of land or belt of trees. The site should not be near a brickyard or graveyard, or a sewage farm or infectious hospital. The worst site is a hollow of bad gravel on a clay substratum and high subsoil water; the best is at the top of a slope on sand or gravel, with low permanent subsoil water. A site on the banks of rivers is not very healthy. Porous soil is best, and, next to that, rocks, granite, clay, chalk. Subsoil water is best 15 ft. below the surface, but should not be less than 10 ft.

Three points should be remembered—the aspect and exposure to wind, sun, and air, the nature of the soil, and the surroundings.

The amount of sunshine received in a room facing east is five hours in the morning, excepting in winter; facing south-east, eight hours in the summer, and three in winter; facing south, from 7.30 a.m. to 4.30 p.m.; facing south-west, from 10.30 all day; facing west, from 1.30 all day.

Warm Climates. We now turn to the question of climate. A warm climate has a temperature of from 80° to 84°, and produces sunstroke, cholera, yellow fever, etc. A temperate climate has a temperature of from 50° to 60°, and produces ordinary English diseases. A cold climate has a temperature of from 32° to 40°, and produces scurvy.

Warm climates are good for people suffering from lung diseases and rheumatism; hot climates for abdominal diseases; cold climates for lung diseases. Continental climates (as Asia) are cold, and the West wind is cold and South hot. Insular climates (Europe) have a mild West wind and cool South. Mixed climates (North America) have a cold West wind and a cool South. Hot climates enervate, because the tissue changes are so slow; one is more healthy where they are rapid. The most unhealthy climate is that on the coast in the tropics. Tropical climates are very much more unhealthy than they need to be, on account of the effect which heat has on filth.

Humidity in the air increases the effect of hot climates and lessens that of cold, because it retards the evaporation.

In a very dry climate evaporation is too great. In health, 75 per cent. of saturation in the air is best. The wind increases the evaporation. For people between 40 and 80 years of age, the colder temperature is the more healthy.

The Healthiest English Climate. A hot summer and a high death rate go together. A rise from 58° to 62° in summer will often bring on an increase of 15 per cent. in the death rate. The healthiest permanent English climate is from 50° to 55° F. Europeans do not flourish when the mean temperature is 20° above our own. Cold that may be well borne in health cannot be borne in sickness or old age, but in phthisis is well withstood.

Shade heat is worse and harder to bear than sun heat. If the sun heat be 120° the shade will be 90°. Winds also affect climates; the Föhn, Mistral, the Sirocco, and the East wind are examples of this.

The climate of the sea is equable, while that of continents is unequal. Drainage raises the temperature by drying the land. All vegetation increases humidity and tends to lower temperature. The electrical state of the atmosphere is also a factor in climate.

Warm climates are of three sorts—humid, as Madeira; moderate, as New Zealand, Great Britain, Algiers: dry, as the Riviera and Australia.

Island and shore climates are the purest and best and are full of ozone. They are excellent for convalescence, scrofula, and depression, but not for irritable nerves.

Climate by the Sea. Ocean climates are good for lung diseases. England, with a range of temperature of 20°, is most healthy.

On the shore, the breeze is generally from the sea from sunrise to sunset, because the land radiates heat quicker than the water. It is from the land from sunset to sunrise because the earth cools more quickly than the sea.

In districts near the sea there will be a great rainfall, no dust spores, but light variable winds. It is good for residence, and increases the expansion of lungs and the rapidity of tissue changes. It is good for phthisis, overwork, general convalescence, and as a prevention of cholera. It is not good for bronchitis, heart disease, chronic rheumatism, or old age.

The climate of woods and forests is cool but equable and sheltered, and is good for chronic bronchitis, heart disease, and irritable nervous diseases.

Desert climate, as at Helouan and Assouan, is good for chronic rheumatism.

The vital activity varies with the season of the year. In winter and spring respiratory diseases are rife; in winter the vital activity is at a maximum; in spring it is at a maximum and decreasing; in summer it is decreasing to minimum; in autumn it is at minimum and increasing; in summer and autumn digestive diseases are most rife.

Continued

continued from page 5216

PORTABLE MACHINE TOOLS

The Advantages of Portable Machine Tools. Floor-plates. Portable Machines of Reciprocating and Rotary Types

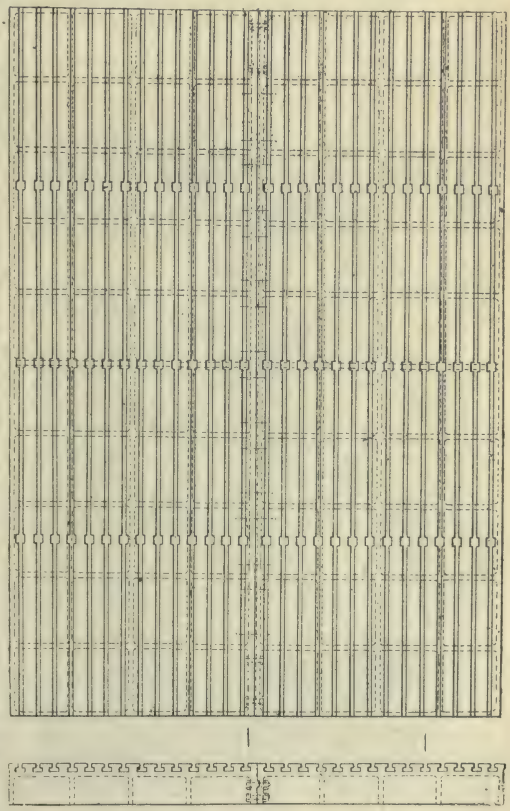
By FRED HORNER

THE machine tools which have been previously treated are all of fixed type—that is, they are fastened down to the flooring of the shop or upon special masonry or concrete foundations. In all such cases the work has to be taken to the machines to be tooled.

There is another important class of machines, the use of which is rapidly increasing, that of the *portable* types, which may be carried about anywhere and set to work on massive pieces, or upon light jobs. Two main reasons may be cited for the employment of such machines. In the case of very heavy castings or forgings, it is often inconvenient and costly to move them about the shop to the different tools, and difficult to adapt the latter to operate suitably; and on large mechanisms in course of erection the fixed tools cannot be brought into use. Apart from the trouble of carrying massive castings to and fro in a shop, there is the question of cost of machines, which, to hold such work, would need very large beds or tables, and arms or rails of great span to reach over and cut upon the various portions. In following such methods, there would also be a lot of re-setting and clamping to ensure the different sections being tooled correctly, which setting would often consume more time than the actual cutting, on account of the awkward shapes, necessitating much packing and blocking up.

The Uses of Portable Tools. Again, after the erection of an engine or other mechanism has begun, there is frequently a good deal of machining to be done as the work progresses, especially drilling of holes, the locations of which cannot be determined at the beginning. If no portable tools were available, the work would have to be done with hand tools, or the portions dismantled, and taken back to the machine shop, obviously an uneconomical procedure. In those works which are unprovided with suitable portable machines one often sees a good deal of chipping and filing done on the smaller areas, to avoid sending them to the shop, and a large amount of drilling and reamering effected with the ratchet brace, worked by hand. Both of these methods are slow, and not always accurate, so that a demand has grown for special tools that can be taken to the job, and affixed to it in any position, to plane, shape, slot, mill, drill, ream, tap, grind, or polish any sections. These portables are of comparatively small size, and correspondingly cheap by comparison with big fixed machines, with their expensive foundation, and their handiness is such that an operation may be completed in certain instances long before the job could have been taken to a fixed tool, set correctly, and bolted down. It is a case of adjusting the tool to the work, instead of vice versâ. The amount of power consumed in moving the light parts of a portable machine is less than that required by a fixed class of machine of similar capacity, the advantage being due to the difference in mass.

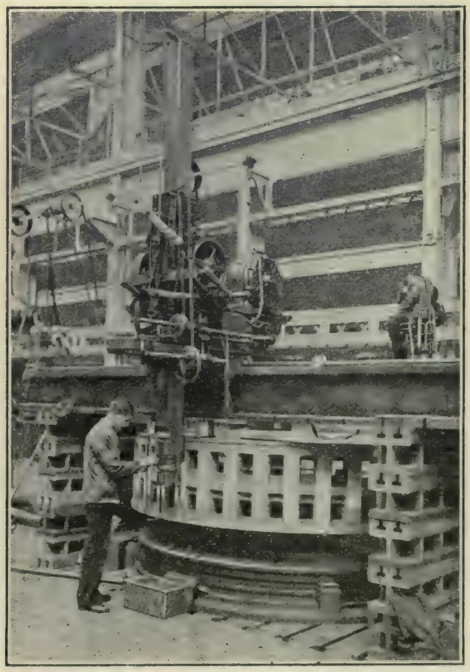
Types of Portable Machines. There are three kinds of portable machines—those placed upon a plate in the shop and moved about around the work, those which are attached direct to the work, and the light ones which are simply held in the hands and presented to the work. The last method is possible only in the lightest classes of operations, and is confined chiefly to drilling and tapping, chipping, caulking, riveting, and grinding. The question of whether the tool shall be attached to the work or to a plate alongside is often one of relative convenience, and may depend on the character of the operations to be performed. If a large casting has to be planed, shaped, or slotted, and then drilled or milled on various faces, it is better to fix it firmly, and shift the tools about into different positions to suit the



97. FLOOR PLATE

requirements. This is called *floor* or *surface plate* work, and is carried out most extensively in the large electrical factories, building dynamos ranging up to 30 ft. or more in diameter, the segments of which are handled on floor-plates. Engine builders also employ *floor-plates* for tooling some of the massive beds, standards, and flywheels.

Floor=plates. The floor-plate provides a large, flat area, upon which work may be set accurately, and held, while the machines are placed where desired to operate on the different parts. The plate is practically one large foundation or table common to a number of machines, instead of belonging to one only. As the accuracy of the work done depends on the condition of the plate, it is constructed strongly, and set with great care. Cast iron is the material used, and it is built up with a number of sections bolted together to form a sufficiently large area to carry one big piece of work, or several sets on different portions. Figure **97** gives a plan and elevation of a moderate-sized floor-plate (Francis Berry & Sons, Sowerby Bridge), measuring 20 ft. by 14 ft. It is of hollow form, 1 ft. 2 in. in depth, and provided with longitudinal and cross ribs, seen dotted. The plate is built up in two pieces, jointed along the centre with a tongue and groove, and secured with forty bolts. There are 28 longitudinal tee-slots for $1\frac{1}{4}$-in. bolts by which the work and the portable machines are secured. Gaps are made at three locations, as seen in the plan, to enable bolts to be lowered into the slots and moved along to position, instead of having to start them from the end, and slide them right along. Apart from the time thus saved, it might often happen that a slot would be covered by some portion that would prevent the bolts being slid past. The top of the plate is planed all over, and



98. PORTABLE SLOTTER TOOLING WESTINGHOUSE ARMATURE SPIDER

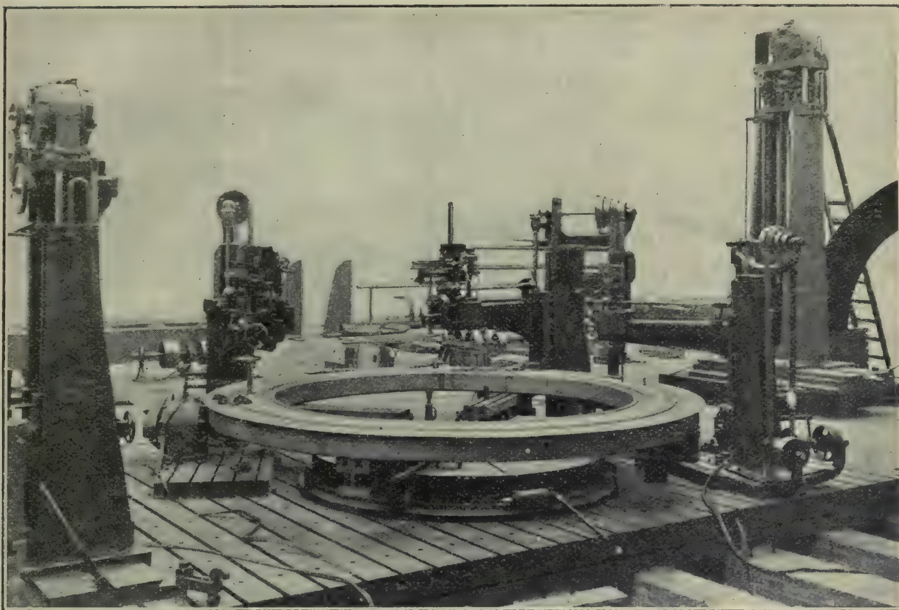
the edges are also planed to serve as guides to set by. The term *marking-off table* is also applied to this plate, because from its true face surface gauges, squares, etc., may be operated to mark out work by, just as it is done on the smaller marking-off tables in the machine shop. These instruments are also employed to set the castings, etc., truly upon the plate in readiness for the tooling. It is obvious that with a job thus placed upon its plate, and machined by tools also resting on the plate, the results must be as true as though the piece was set on an ordinary planer or slotter or drilling machine.

A Large Floor=plate. Plates larger than this example are necessarily built up of a number of pieces fastened together. Probably the largest plate in use is that of the Westinghouse Electric and Manufacturing Co., at Pittsburg, employed for the machining of large generators. It measures 176 ft. long by 48 ft. wide, and is composed of 132 sections, each 8 ft. square, bolted and keyed together. An ample foundation is afforded by brick piers, 12 ft. deep, standing on a bed of concrete, 3 ft. 6 in. thick, the piers being spaced 4 ft. apart, and connected by brick arches. All the space between is filled in, and finished with concrete, the top of which comes about 5 ft. below the underside of the floor-plate. The object of this is to form a chamber into which cuttings may fall through holes in the bottom of the tee-slots, and be removed by doors communicating with the chambers. The latter may be flushed out with water when necessary. Powerful travelling cranes run overhead above the plate, to handle the work and the machines on it. The total weight of the cast iron in the plate is about 1,000 tons.

Between such a plate as this and the one in **97** various sizes are made, according to the requirements of the shop. Even if the work handled is not very large, the plate may have a considerable area, in order that two or more sets of work may be put on it at once. If there are not enough machines to operate on all the pieces simultaneously, the advantage is still gained that setting and bolting down may proceed at one part of the plate in readiness for the tools when they are free to leave other work elsewhere.

Floor=plate Work. The photographs showing views of floor-plates in operation will help the reader to understand the methods of working, and the drawings of the portable machines following indicate the features which are special to these types. Figure **99** gives a general view of a portion of the floor-plate at the works of the British Westinghouse Electric and Manufacturing Co., Ltd., Trafford Park, Manchester. The photograph was taken before one of the sections had been put into place, so that the brick piers are seen at the bottom of the picture. The object being dealt with is a large ring, supported on blocking attached to a revolvable table, and three radial drilling machines are drilling holes around the ring. The latter is revolved at intervals to bring it into fresh positions for other holes, the machines therefore remaining stationary. Figure **98** shows another use for the revolving base-plate, the object being an armature ring, or spider, which is bolted to the plate and given partial rotations to come under the ram of the portable slotter, which is elevated upon packing blocks above the work. As each slot is made in the periphery, the table is turned sufficiently to set it for another slot. The operator is seen testing the setting. If a large circular object like this were done by the fixed machine, it would necessitate the use of an abnormal table on the slotter.

In **100** an operation with a drilling machine inside the work is shown. The machine is of pillar



99. FLOOR-PLATE WITH RADIAL DRILLS AT THE WESTINGHOUSE WORKS

type, with a spindle driven in a bearing that is adjustable up and down within the pillar. The drill is thus moved to any position. In the photo it has already put through one hole in the generator yoke, and is engaged on another above, these holes serving to attach the pole-pieces. By turning the entire machine upon the circular table (mentioned above), it is made to align with the other holes inside the ring.

Tooling of another class is illustrated in **101**, the machine being a rotary planer or face-milling machine, of the class described in the last article, with a number of tools pinched in holes in a large revolving disc. The latter is mounted on a spindle running in bearings in a sliding carriage, that moves down the long bed and so makes the milling cutter face off the work, feed for depth of cut being imparted by a transverse slide on the carriage. The work shown in the photo is the bottom half of a steam turbine casing, blocked up with angle plates and screw jacks on the floor-plate, while the bed of the milling machine is clamped with bolts and clips.

A large amount of facing work is done with machines of this class as an alternative to putting the job on a planer or slotter. Joints of flywheels and of dynamo segments are typical examples of awkward pieces which are best treated upon floor-plates, while many kinds of beds and bases are well suited to the method of working. There is also some saving of time by milling, over planing, or slotting, in work of the character shown in **101**, in which a single-pointed tool would have to " cut wind " for a good deal of the time in passing over the gaps.

A considerable amount of packing of various kinds is used on the plates, including plain parallel strips or bars, girder-shaped pieces, and castings with tee slots to carry bolts which clamp work down, as seen in the views **98** and **99**. These are necessary to raise the work off the plate sufficiently to let the cutting tools clear, or to elevate the portable machines into suitable positions. Sometimes also the castings may have projecting lugs or bosses which prevent their being laid on the plate to stand without rocking about; by slipping a packing block under each end the projecting portion is raised clear off the plate.

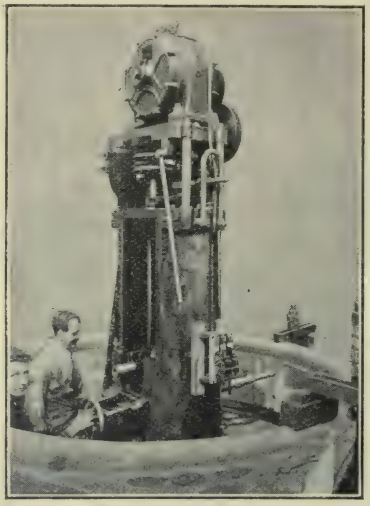
Floor-plates, like planing-machine tables, usually have their surfaces provided with a number of round holes, into which stop-plugs are inserted to resist the thrust of cutting, and so to relieve the holding-down bolts to a certain extent, and prevent risk of a sudden slip during tooling. The usual clamps and bolts for planer work are employed on plates to hold down the work and the machines. Large numbers of wood blocks and struts are used to support the free ends of clamps which press upon the work, the wood being lighter than iron packings, and nearly as satisfactory for the purpose, although for packing up the castings or the machines, the more rigid and unyielding iron blockings are better. Screw jacks, for adjusting the height of castings, are found on most floor-plates; they are more convenient to use than wedges, affording a steady lift, with great precision of movement. The service of an overhead crane is necessary in the first place to carry the work to the plate and hold it until blocked up, but after that the final small adjustments can be effected by the jacks. Hydraulic jacks are sometimes applied where the weight of the job is excessive.

Setting Work on Floor-plates. The setting of large pieces of work on floor-plates involves the use of special instruments which are not found on ordinary machine tools, including large squares and straightedges, and various gauges. For example, in setting segments of large dynamo rings some means must be found of gauging the radial setting, and of marking out the inside for slotting the facings which hold the pole-pieces. A central pillar is clamped on the plate, and a long radius rod pivoted from it to reach out to the segment,

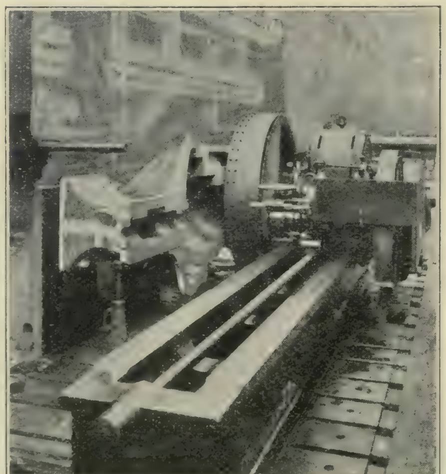
which is fixed down at the correct distance. The truth of the circular setting is then tested by slewing the rod round on its pillar. The setting of the portable slotter or drill is also tried by a rod.

An interesting method of laying out big work has been adopted at the Westinghouse works at Pittsburg. A number of huge generators for the Manhattan Railway Company were ordered, having a total height of 42 ft., the revolving portion being 32 ft. in diameter, and the devices then in use for dealing with work of the kind were deemed inadequate to cope with the abnormal machines to be built. It was feared that errors would creep in as regards the machining of the segment joints and the drilling of the bolt holes, and a novel departure was made by the employment of surveyor's methods, using a dividing and levelling instrument mounted upon a column bolted to the floor-plate. The ring segments were each in turn packed up and clamped at the correct radial distance from the centre pillar, the testing being done by a centring gauge pivoted on the pillar. The correct angles of the joint faces were then determined by sighting with the instrument mounted on the pillar, and straightedges were clamped to the plate in exact radial positions as found by the instrument. The base of the portable slotting machine was then set parallel with a straightedge, adjustments being effected with setting screws, clamped down, and the segment joint tooled across, the slotter being moved subsequently to the opposite end. The bolt holes in the ends were afterwards drilled, using a jig plate to bring them all alike in each segment. After putting together the lower half of the ring, it was tested with the instrument to note whether the joint faces coincided with the centre of rotation, the result being satisfactory. Other tests showed that the machining had been performed very accurately.

The instrument was employed also in dividing round the periphery of the rotary portion of the generator, to locate the positions of the slots. The operations were carried out on the large floor-plate mentioned previously in this article, and the methods are still followed by the company in dealing with their large floor-plate work.



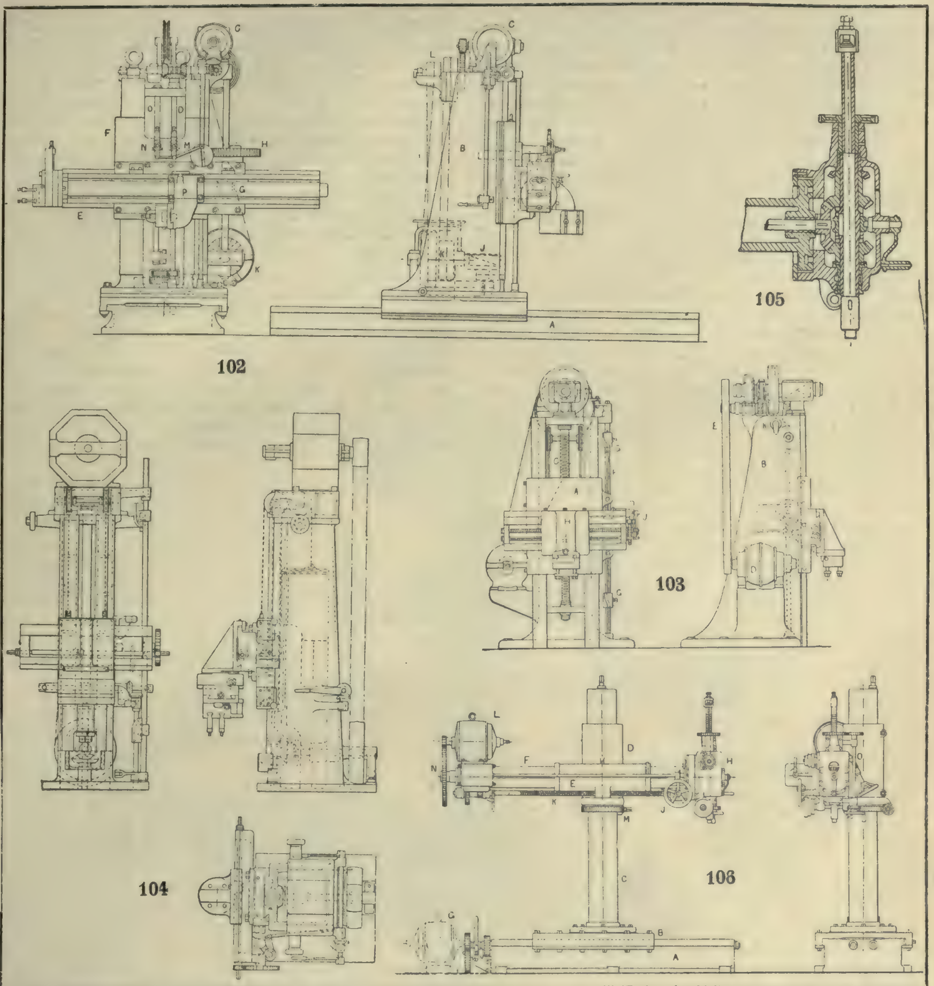
100. PORTABLE PLANER OR SHAPER



101. PORTABLE ROTARY PLANER AT THE WESTINGHOUSE WORKS

Floor-plate Machines. Coming now to details of the machines used on these plates, we find that they have certain points in common with ordinary machine tools, as regards slides, spindles, feeding and adjusting devices, but the forms of the framings may differ somewhat, and the methods of driving are not similar, on account of the new conditions to be met. A portable machine must obviously be free to move about to any required position, and it is impossible to encumber it with belts, or tie to it any countershaft positions. Happily the electric motor has solved this difficulty, enabling machines to be shifted about anywhere, and the power to be supplied through flexible cables, which may lay along one of the tee slots or lead off in any direction where it is not in the way. Several cables are visible trailing off the plate in **99**. Previous to the introduction of the electric drive, a moderate amount of driving was done by means of round ropes, rotating vee'd pulleys on the machines, and allowing the latter to assume any angular positions. Ropes are still employed for some classes of work, as we shall see later; but the many advantages of electricity have caused the older system to be largely ousted. The disadvantage of having running ropes about the work is obviated by the motor drive, in which the moving parts are contained entirely on the portable machine, so that it may be placed in very awkward or confined situations without regard to surroundings.

The Portable Planer. The reciprocating machines naturally constitute a large proportion of the types used on plates, and they are well adapted to the planing of joints and faces, including grooves, keyways, and dovetailed slots. Planers or shapers, and slotters are employed, the first-named having horizontal strokes, and the second vertical strokes. An example of a planer or shaper is illustrated in **102** (John Holroyd & Co., Ltd., Milnrow). It is styled a *universal machine*, on account of the complete range of movements possible. The base portion is an 18-ft. bed, A, which is held down on a floor-plate by clamps pressing on the bottom flange. The column B, gibbed to A, slides upon it longitudinally by hand movement with a ratchet lever, or by power, from the $6\frac{1}{2}$-h.p. motor, C, which makes 500 revolutions per minute. There is a spur gear drive from the motor shaft to one immediately below it, whence mitre gears (seen in the left-hand view) drive to a nest of bevel gears on the

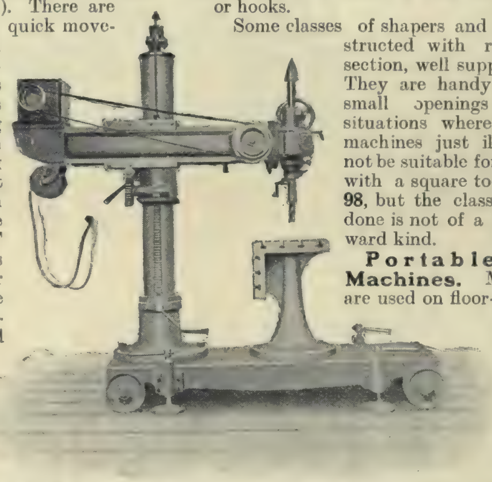


102. PORTABLE SHAPER 103–4. PORTABLE SLOTTERS 105–6. PORTABLE DRILLING MACHINES

top of the column, combined with a claw clutch by which the shaft D may be revolved in either direction. D passes down the column and drives a train of spur gears ending in a pinion that engages in a rack fastened to A, so that when the train is set in motion the column slides along. The base of the column is of circular form, fitting on the saddle below, that slides on A, and the edges are indexed so that B may be revolved to any angular position, and clamped by the bolts seen in the left-hand view on the base, this provision enabling the ram to be faced round, to shape work at any angle without troubling to shift the bed, A. The ram slides in a saddle, F, fitted on the front face of the column, and is driven to and fro by a pinion and rack, G, rotated by a spur gear, H, which derives its motion from a pair of bevel gears, J, driven from the sets of fast and loose pulleys, K, operated by other pulleys, L, at the top of the column, also driven from the motor through spur gears. The difference in diameter of the sets of pulleys K and L, affords a slow rate of cutting and a quick rèturn, a device already described in connection with planing machines of standard forms. The belts are shifted by forks actuated from adjustable dogs on the moving ram, E. At each stroke a partial rotation is given to the disc, M, which rocks a lever connected to two ratchet pawl levers, N. These effect partial turns of ratchet wheels, operating mitre gears which transmit their motion either to the shaft, D, or to a screw, O; if the first, the result is that the column, B, is moved along its bed, A, a little after each cut taken by the ram; if the second, the saddle, F, is fed similarly up or down the column, so that the surface of the work is gradually covered either in a vertical or a horizontal plane. The tool-box at the end of the ram may be angled upon a circular facing, to point the tool into corners; a clapper-box fitting is provided for relief. Another box, P, is bolted to the front of the ram to do face planing where the box

at the end cannot be conveniently applied. Other points which may be noted in this machine are that the saddle, F, is counterbalanced with a rope passing over the pulley at the top, holding a weight (not shown) inside the column, and that there are a couple of eye bolts let in the top of the column, by which the entire machine, which weighs about 13½ tons, may be hoisted with the overhead traveller and carried to any part of the floor-plate. The stroke of the ram, which is 4 ft., is arranged to return at double the cutting speed.

Portable Slotters. The vertical slotters are employed for tooling work that has deep vertical faces of no great width, the machine [**103**] being made without a long bed. This machine, also by Messrs. J. Holroyd & Co., Ltd., is constructed with a saddle, A, moving upon the face of the column, B, the mass being counterbalanced by a weight inside the column, suspended with two wire ropes. The vertical stroke of 4 ft. 6 in. is obtained from a large, square-threaded screw, C, working in a nut on the back of the saddle. The 5-horse power motor, D, is belted up to a pulley, E, that connects to bevel gears on the top of the screw, through intermediary spur gears (covered with guards). There are two available ratios of slow and quick movement by these gears, thrown in and out by a friction clutch between the top pair. The clutch is actuated through a series of levers worked from the rod, F, carrying two adjustable dogs, GG, which are struck by pins on the moving slide, A, and given a partial twist through the medium of cam grooves on their outsides. At the same time that the twisting of F produces the reversal a feed is given to the tool-box saddle or to the box slide itself by mitre gears driven from F and communicating with a crank disc and ratchet and spur gears situated at J, the effect being similar to that of the mechanism already described in connection with planing machine feeds. The cross motion of H is limited to 2 ft. 6 in. There are two lifting hooks, one of which is indicated at K, and the base of the column has several bolt holes.



107. PORTABLE DRILLING MACHINE MOUNTED ON TROLLEY BASE

It may be noted that the bottom edges of such machine bases are planed square in order that they may be used as guides to set the machines by—a simple and ready method which saves much time.

A vertical slotting machine having 4 ft. stroke is shown in **104** (John Hetherington & Sons, Ltd., Manchester). The interesting feature of the design is that the quick return is effected by altering the speed of the motor on the top of the framing, instead of through reversing clutches or other means usually adopted. The motor shaft has a pulley from which a belt goes down to a larger pulley on the base, driving bevel gears, at the front of the frame, which rotates the vertical square-threaded screw that moves the saddle up and down, balancing being done by a weight shaped to suit the inside of the column, and suspended over pulleys by two Renold chains. As the saddle slides, rollers mounted on brackets at the top and bottom corners alternately come into contact with cam-shaped dogs on a vertical shaft just behind the saddle, and twist this shaft, causing it to operate a reversing switch (not shown) that changes the direction of rotation of the motor, and alters its speed. During the cutting stroke of 20 ft. per minute it runs at 350 revolutions per minute, and on the quick return of 40 ft. the rate rises to 700 revolutions per minute. The twisting of the reversing rod also imparts a feed to the cross-slide on the saddle through ratchet and spur gears in a manner that has been mentioned previously. The tool-box, not shown in the front elevation, may be angled upon a circular facing on the underside of the angular bracket sliding along the cross-rail. Provision is incorporated for reversing the motion of the saddle by hand through the handle seen against the column in the side elevation, the movement of this handle operating mitre gears turning a short vertical shaft, which is connected at the bottom, by pivoted levers, to the reversing shaft. The bottom edges of the base are planed true. Some machines of a similar character are raised up on a box base to fit them better for coping with deep work on the floor-plate. There are two lifting snugs standing out from the sides of the column in **104** to afford a hold for the crane slings or hooks.

Some classes of shapers and slotters are constructed with rams of square section, well supported in guides. They are handy for getting into small openings and confined situations where the types of machines just illustrated would not be suitable for use. A machine with a square tool ram is seen in **98**, but the class of work being done is not of a difficult or awkward kind.

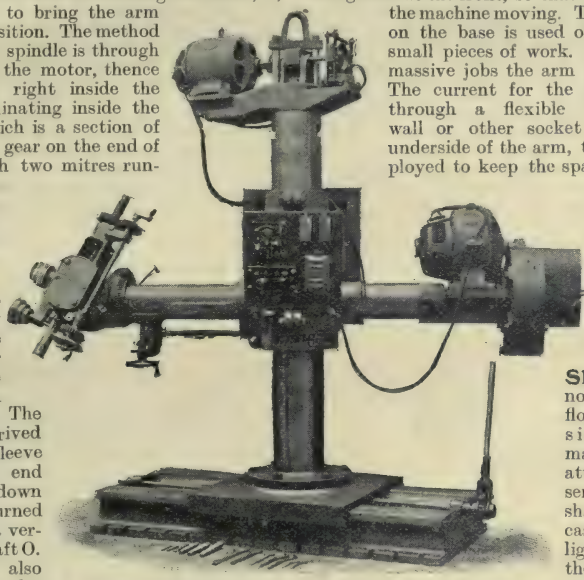
Portable Milling Machines. Milling machines are used on floor-plates, the two principal types being those represented in **100** and **101**. Figure **100** is shown at work drilling, but the style of machine is adapted also for milling, and is especially useful for grooves, which it can finish rather more quickly and uniformly accurate than the shaper or slotter. The other type of miller in **101**, used for tooling off large surfaces, is made with differing lengths of bed, according to the service required. The large cutter heads are driven by a pinion engaging with a ring of teeth inside the rim, which gives a better drive than attempting to drive the spindle alone.

Portable Drilling Machines. The drilling machines form a large proportion of the tools used in conjunction with floor-plates. Sometimes those of ordinary radial types are employed, as seen in **99**, but usually the designs are special, with the object of increasing the reach and capabilities of the tools. The favourite form is that embodying a circular pillar supporting a transverse arm, producing thereby universal movements. In the machine shown in **105** and **106**, the bed, A, receives a slide, B, upon which the pillar, C, is bolted. C is embraced by a sleeve, D, cast with a tubular bearing, E, at right angles, within which is the arm, F. The saddle, B, can be moved along the bed by hand, using a

ratchet handle on the squared end of a screw lying within the bed, or more rapidly by power, with a motor, G, shown dotted, driving the screw through spur gears. There is also another use for the motor, that of driving a splined shaft alongside the screw, communicating with bevel gears to a vertical screw inside the pillar, C, by means of which the sleeve, D, is adjusted up or down quickly. A hand motion may be alternatively produced by the squared handle-end at the top of the screw, seen projecting up out of the pillar. The drill spindle is carried in a head, H, at one end of the arm, F, and the motor for driving is at the other, thus balancing approximately. The arm may be moved through its bearing by turning the hand-wheel, J, connected to mitre gears, which turn the screw, K, working in a nut in E. A power movement is also obtainable from the motor, L, driving to spur gears communicating with the screw, the connection being made or broken by a clutch. The worm gear at M is used for turning the sleeve, D, around the pillar, to bring the arm into any desired position. The method of driving the drill spindle is through the gears, N, from the motor, thence by a shaft passing right inside the arm, F, and terminating inside the head [see **105**], which is a section of the box, H; a mitre gear on the end of the shaft gears with two mitres running loosely on sleeves encircling the drill spindle, and driving the latter in one direction or the other, according to whether a claw clutch between the mitres is slid up or down by the cranked handle seen outside the head. The spindle feed is derived from a screwed sleeve encircling its upper end and moved up or down by a spur gear turned from a pinion on a vertical hand-wheel shaft O. Self-acting feed is also available, effected by the belt cones seen on the side of the head, the upper one being driven from small bevel gears on the spindle sleeve, and transmitting movement down to the lower belt cone, which drives a worm gear, thrown into or out of action by a friction disc device. The head, H, may be swivelled upon the end of F, and clamped with tee-headed bolts. We therefore see that when the base, A, is bolted down, the drill head may be brought into any position around the circle, either high or low, so that a large number of holes at various locations might be drilled expeditiously. In some designs the long base, A, is not used, the pillar terminating instead as a broad circular foot. The horizontal range of the machine is thereby lessened, though this is of no moment in much work, because it is easy to shift the machine bodily to a fresh position. The advantage of the base is that it enables successive movements to be made, to drill a row of holes all in line with each other.

Figure **108** illustrates a machine (by Kendall & Gent Ltd., Manchester) of the same general type as that just described. The motor for elevating the arm is placed on the top of the column, and the pillar and saddle are traversed along the bed by screw and ratchet handle. The drilling head, driven by the other motor, is shown set to an angle, and it may also be set round in the other direction by worm gear on the arm. The switches for starting and stopping the motors are mounted centrally on the board at the front.

Before we leave the subject of floor-plate machines an illustration of a combination class of machine may be given, that in **107**. It has a circular pillar, with elevating sleeve, and sliding arm, and the drive is by motor, but the base is different from the examples we have hitherto considered. It is supported on four small trolley wheels, which enable it to be pushed about anywhere without the need of a crane. When set ready for work, the machine is steadied by raising the wheels off the ground by turning four jack-screws, forcing down flat plates, two being seen at the front, so that there is no chance of the machine moving. The slotted table seen on the base is used only for dealing with small pieces of work. When dealing with massive jobs the arm is slewed outwards. The current for the motor is conveyed through a flexible cable led from a wall or other socket to a drum on the underside of the arm, the drum being employed to keep the spare length rolled up neatly. Although this machine may be used for floor-plate work, it is more often employed on the ordinary shop floor, or out of doors.

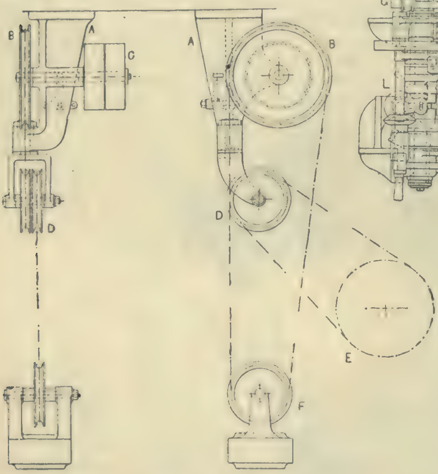


108. ELECTRICALLY-DRIVEN PORTABLE DRILLING MACHINE

The Portable Shaper. Leaving now the question of floor-plates, and considering portable machines which are attached to, or presented to the work, we shall see that in these cases the tools are of lighter build, since they cannot have a massive foundation plate upon which to rest. The heaviest tools are slotters and shapers or planers of the kind shown in **98**, the long bed being lowered on to a piece of work, such as an engine frame, to enable the bearings to be tooled or various facings machined, instead of endeavouring to do the work in makeshift fashion on machines that are too small for the work. A good deal of key-seating is done with these slotters, especially in the hubs of large wheels, and some kinds of machines designed solely for keyway cutting are used. Figure **109** gives elevation and plan of a portable horizontal slotter or shaper (Francis Berry & Sons, Sowerby Bridge) which is designed for slotting out keyways in the bores of very large flywheels, etc., while they are still in the lathe, after boring. The machine is also applicable to tooling faces on big castings that cannot be conveniently put on an ordinary planing machine. The maximum stroke is 30 in. The base, A, well provided with bolt slots in the bottom flange, supports a saddle, B, by vee'd edges. The ram, C, slides in vee guides in B, and its

tool-box, fitted with relieving clapper, has a small vertical feed, given by hand through the medium of a vertical screw, operated by mitre gears from a shaft passing back to the middle of the arm, where the handle is situated so that it will not come foul of the work when tooling deep bores. If the handle was placed direct upon the screw, as in ordinary tool-boxes, the operator would have no chance of reaching it. The tool-box can be turned upside down for keyways on opposite sides.

The machine is rope-driven through a large pulley, D, the rope being kept in its grooves when running at various angles by four grooved guide pulleys, E, E, E, E, lying above. There is a spur pinion on the stud of D, gearing with a wheel, G, on a shaft passing across at right angles to the ram, in bearings supported in a bracket casting bolted to the side of the bed, A. On

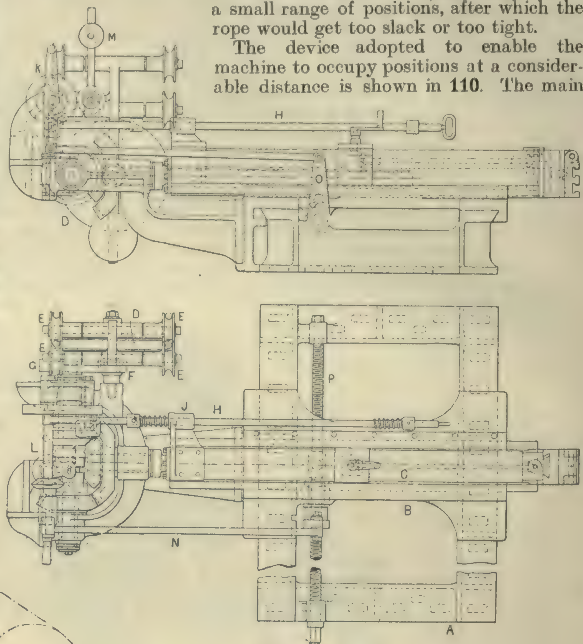


110. ROPE DRIVER

this shaft there are two loose bevel wheels engaging constantly with large and small bevels keyed on the end of a driving screw which actuates the ram. A friction clutch between the bevels throws either pair into action, so that it revolves with the shaft, the object of the differently-sized pairs being to produce slow cutting and quick return movements of the ram. The self-acting motion is derived from the rod, H, having two adjustable dogs, with cushioning springs which are struck in turn by the faces of the bracket, J, on the moving ram. The rod, H, rocks a lever, K, on a shaft, L, connected by bevel gears, seen in the plan, to the clutch-shipping lever. A rocking weight and lever, M, is connected by spur gears with L to retain the clutch in each of its positions after reversal. An automatic feed for the saddle, B, along its bed, is obtainable through the motion of the shaft, L, reciprocating a rod, N, connected to a lever, O, which by a ratchet and wheel effects partial rotations of the feed screw, P, working in a nut on the lower side of the saddle, B. The screw, P, is extended at one end and squared to receive a crank handle for the purpose of making adjustments.

The rope-driving arrangements are of an interesting character because of the necessity for introducing means of keeping the rope taut at all positions of the machine. It is evident that an ordinary pulley fixed overhead in the roof and connected by a rope to the machine pulley would only work in a small range of positions, after which the rope would get too slack or too tight.

The device adopted to enable the machine to occupy positions at a considerable distance is shown in **110**. The main



109. PORTABLE SHAPER

bracket, A, fastened overhead, forms a bearing for the shaft of the rope pulley, B, driven by the fast pulley of the pair of belt pulleys at C, the belt being thrown off when required to the loose one through the shipper lever seen behind the bracket, operated by dependent cords. A pair of smaller pulleys, D, are mounted in a forked bracket that may turn freely in a horizontal direction, by means of its circular stem held in the bottom of the bracket, A, with a nut. This fitting allows the rope to slew round to any angle which the portable machine may demand. E represents the pulley of the shaper, although, of course, in actual work it is separated by a long space from the pulleys, D. A weighted pulley, F, is employed to compensate for the varying distances of E from its drive, the endless cotton rope passing down from B to F, which maintains a constant pull upon it, thence round one of the pulleys, D, from that down to E, back again around the other pulley, D, and so up again to B. Should E approach D, then the weight, F, goes down and absorbs the slack rope; if E goes further away, then F rises and pays out more rope. It is clear that a flat belt could not be made to drive in such a flexible manner as the rope does, and it is applicable only in cases where the position of the shaping machine is fixed within a narrow range, a jockey pulley and weight taking up the limited amount of slack which is developed. As we have already said, the greater convenience of the electric drive has had the effect of largely displacing these belt and rope drives, although for shops and situations where electric power is not available they still hold their own.

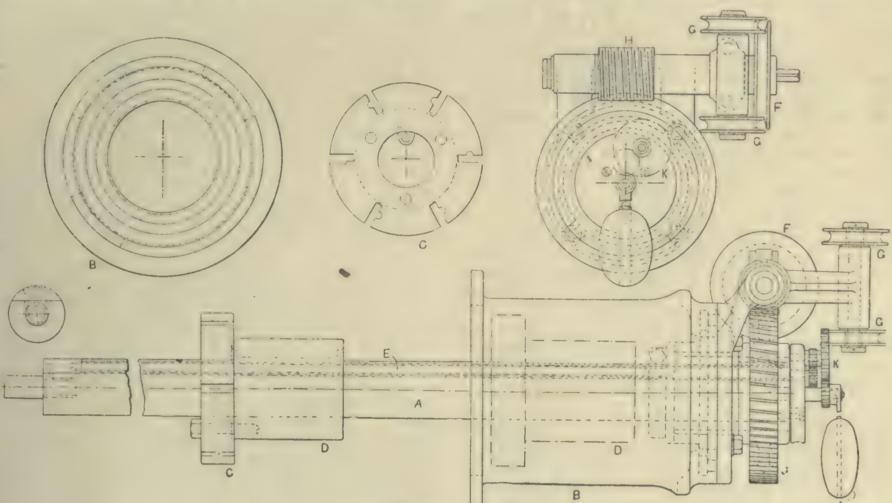
Portable Cylinder Boring Machines. An example of a rope-driven portable cylinder boring machine by James Spencer & Co., Hollinwood, is given in **111**. These classes of machines are not used for original boring, but for reboring locomotive cylinders after they have worn badly. It is often more convenient to be able to true out the bores without troubling to dismantle the engine and carry the cylinders to a fixed machine. The cuts taken are necessarily light, so that the machines do not have to do very hard service. There is no difficulty as regards the attachment of such machines to the cylinders, because the faced ends which take the cylinder covers afford excellent resting-places for the fixed parts of the machines.

In **111** the boring bar, A, is encircled at the driving end by a hollow socket, B, the front face of which bolts to the cylinder end. At the tail end of the bar there is a smaller diameter, that runs in a hole in a stretcher plate (not shown), spanning across the mouth of the cylinder, and bolted to the flange. The two bearings thus afforded keep the bar exactly in the centre of the bore being trued out. The cutters are held in the head, C, by half-round wedges fitting in the semicircular grooves on one side of the cutter slots. Two or three sizes of heads are available, and any one may be used, by screwing it to the face of the sliding sleeve, D. The latter has a nut sunk partly into the upper side of its bore, within which runs a longitudinal feed screw extending the whole length of a groove in the bar, A. The sides of this nut also form a kind of key, by closely fitting the groove in the bar, so that the sleeve, D, is positively driven round as the bar rotates. The socket, B, is made large enough end face of B, and tightened with tee-headed bolts in a circular slot, so that the rope pulleys may be presented at any angle to the vertical. The automatic feed of the boring head along its bar is produced by differential gears, seen at the driving end of the bar. The first one is mounted loosely on a stud screwed into the bar, and is connected to a lever having a heavy elliptical weight suspended from it, the effect of which, hanging down, is to keep the spur gear stationary, as though it were gripped by some outside clamping device.

This stationary gear has 24 teeth; as the bar revolves, a larger gear of 60 teeth, K, circles around it, and, by the difference in the numbers of teeth, receives a slow revolution on its own axis which is transmitted to a 27-tooth pinion on the tail of the screw E, through an intermediate gear of 18 teeth. While the bar is revolving, therefore, the screw F is turning and feeding the sleeve, D, with its cutter head, C, along very slowly, so that it gradually passes through the cylinder bore. The bar in this machine is 5 in. diameter, and its length is 70½ in. The largest cutter head is 13½ in. diameter.

These useful machines are also constructed to drive by other methods than rope. Hand driving is very frequently adopted where there is no power of any sort available, the place of the rope pulley on the worm shaft being occupied by a flywheel with handle. An electric motor is employed in some machines, driving through spur gears to the worm.

Crankpin Turning Machine. A special machine used also for locomotive work is that for turning up crankpins while in place. The principal element is a right-angled bracket, the foot of which



111. PORTABLE CYLINDER BORING MACHINE

inside to accommodate the boring head, as shown by its dotted outline, so that it may begin to bore from the end. The rotation of the bar is effected through a cotton rope driving the pulley, F, smaller guide pulleys, GG, being located on an arm on each side of F. On the spindle of F there is a worm, H, engaging with a worm wheel, J, keyed to a sleeve on the end of the bar, A. The bearing which carries the worm spindle can be swivelled around on the is clamped to the spokes of the wheel. A bearing lying in line with the crankpin carries a shaft with a point centre entering into the countersink in the crankpin end, and a large spur wheel on this shaft is driven by a pinion and handle, or rope wheel. A slide is fastened to project over the pin, and if a tool is clamped in the holder it will travel around the pin and turn it, longitudinal feed being obtained from the end motion of the tool-holder slide.

Continued

LAND AND ESTATE AGENTS

Entering an Office. Qualifications and Premium. Examinations. Starting in Business. The Agent and his Staff

By F. H. WORLEY

IT is our intention in the following columns to discriminate between the two branches of the profession, pointing out the necessary qualifications or special knowledge required for the duties of each, and weighing their advantages and differences.

Qualifications. There are certain natural qualifications which are especially desirable for an estate and land agent to possess. He is placed in the position between landlord and tenant, or proposed purchaser—a situation demanding the exercise of considerable tact—in order that he may bring business to a termination satisfactory to both parties. His demeanour towards the tenants must be courteous but firm, and this demands good judgment as to the exercise of severity or leniency; he must also be observing, persevering, and enterprising.

To the casual observer, the land and estate agent are one and the same, and it is only on more closely examining the details required for the proper performance of the work of each that the division under two headings becomes apparent. To those whose ambitions turn in one of these directions there are matters which must, to a large extent, be considered as personal, such as capital at disposal, and possibilities of working up a connection. In starting a town (estate) agency, for instance, these are comparatively of minor interest owing to the growth of districts and properties continually changing hands, whilst in a country (land) agency there are the important considerations of personal influence (without which it is almost useless to consider this as a career), the necessity for an intimate knowledge of rural life, with either the prospect of an appointment to an agency or agencies, or a partnership.

The Agent's Duties. An estate agent is called upon to deal with a large variety of matters, from the handling of small weekly property, let, perhaps, at a few shillings per week. to mansions and business premises, etc., at considerable rentals. He must, therefore, be able to determine the full annual value of the same, and be a good negotiator so that he may let them to the best advantage. He must be able to undertake the collection of the rents when let, and the supervision of repairs, for which a general knowledge of building construction is advisable. He should also have a fair knowledge of the law referring to property, so that he is in a position to satisfy his clients that by placing their property in his hands their interests are best served, and money and time economised.

The advantages of an outdoor life and its social opportunities are undoubted, but against these must be set the greater variety of detail with which a country agent should be acquainted, and the necessity for an intimate knowledge of the properties in the district in which he is interested, the nature of the soil, crops, etc. He should also have a considerable acquaintance with the tenants, tact in dealing with the matters of rent collection and management, and a general knowledge of the laws and customs affecting landlord and tenant as applied to the country—the Agricultural Holdings Act, etc.

The Allied Professions. Professions frequently allied to that of the estate and land agent are those of the surveyor and valuer, and often of the auctioneer. As regards the surveyor, it is obvious that the continual handling of plans and specifications form part of his ordinary duties; and alterations or differences which may arise are matters which are best dealt with by a specific knowledge of their requirements. As a valuer, it is more than probable that the estate agent's intimate acquaintance with the property in which he deals places him in the best position to supply the necessary information; and to enable him to legally charge for his expert opinion it is only necessary for him to take out a licence at an annual cost of two guineas. For the same reason, the duties of an auctioneer can be well filled by him, and the fees and commissions accruing from sales may add to his income a not inconsiderable amount which would otherwise be diverted into other sources, frequently with less satisfaction to the vendor and purchaser. At the same time the transaction of such business will probably add to his connection [see also AUCTIONEERING].

It must, however, be borne in mind that a ready flow of language and quick repartee are necessary assets in this profession, an auctioneer being frequently called upon to exercise skill in his powers of description and persuasion, and in grappling with any awkward questions that may arise. An auctioneer's licence costs £10 annually.

Having briefly distinguished between the branches of the profession as followed in town and country we must further investigate the necessary training required for a successful career in either direction. We have seen how, to a large extent, the immediate environment, or at least the early years spent in a city or provincial life, will have considerable bearing on the ultimate success. It is easily seen that a youth whose daily surroundings are not limited or confined to streets and buildings, and whose conversation, habits, and acquaintances are naturally more or less imbued with the common interests of the country-side, will have an instinctive grasp of subjects that could be only superficially acquired by a town-bred student after laborious book research. In short, there would be all the difference between a practical and a purely theoretical knowledge. On the other hand, in a city life the eye is familiarised with a far greater variety of buildings; structural operations are constantly in progress, and there is the more immediate contact with all branches of commerce—an all important factor in the preparation of an estate agent's education

ESTATE AGENCY

Taking an estate agency first in order, we will enumerate the various steps necessary for a youth leaving school to enter the profession, presuming that he is in possession of a fair, elementary, commercial education. The first matter of importance is the selection of a suitable office where the routine may be thoroughly mastered in all its branches. Hence we do not advise entering a very large office at first, as it is probable that in the

comparatively brief period of the youth's indentures too much time would be occupied in departmental work, to the exclusion of a more general experience.

The Agreement. The all important selection having been made (taking into consideration the question of premium), it is customary, in the interests of both parties, that at least a month's trial should be given, so that the proposed pupil may have an opportunity of definitely deciding whether the career will be to his taste, and that the principal may have an opportunity of determining the proposed pupil's suitability. On both sides important decisions have to be made before a binding contract is entered into. The term of probation having expired, by mutual consent a deed of indenture is drawn up, whereby the parties enter into an agreement commonly known as *Articles.* This document generally embodies most of the old apprenticeship clauses, especially as regards obedience and punctuality, and stipulates that the pupil shall further the interests of the master to the best of his ability, etc. It is usually entered into for a term of three years; it specifies the agreed amount of premium, and further sets forth that it is entered into by the pupil of his own free will and accord, and, if he is under age, by the consent and approbation of the father or guardian. It mentions the profession or professions he is to learn, the period the indentures are to last; that he shall faithfully serve his master, keep his secrets, and obey his commands; not absent himself unlawfully, and shall in every way act as a faithful apprentice. On the other hand, the master agrees "to teach, or cause to be taught, and instructed by the best means in his power," the art, trade or business of an estate agent, etc., etc.

The Premium. The amount of premium is a matter for negotiation; as a basis, however, we should say £50 would secure entry in a suitable office for a term of three years. This sum may be increased and a portion returned as salary during the latter period of the apprenticeship.

It is not advisable to enter an office where there are many articled pupils. In fact, if there are no others it is greatly to the advantage of the one, as his duties will secure a much more varied insight into office routine. This will include the usual elementary matters, such as indexing, letter-filing, etc., followed by making tracings of plans, copying specifications and inventories. The pupil will be required to accompany his principal when surveys and valuations are being made.

By exercising intelligence and noting the particulars gathered and the reason for their notification, he will accumulate a store of useful knowledge which he will be called upon later to employ without supervision. During this time he should be continually on the alert, watching the procedure of the office business in every direction, so as to be conversant with matters of difficulty and doubt. He will find that the opportunity the letter books present for studying correspondence will be of great assistance, not only as to the replies themselves, but their formula, phraseology, etc.

Concurrently with such daily practice it is advisable, where possible, to arrange that the spare time which may be found at his disposal shall be utilised in reading for some of the examinations. Those of the Surveyor's Institute naturally take precedence, and of these, the Students' Examination, held annually in January, is the one for which we advise early preparation. [See Schedule, page 160.]

Examinations. It is usual to take this examination at about the age of 18 years, and the subjects embraced belong to the ordinary school curriculum. If, however, the student can produce a certificate showing that he has passed the Matriculation Examination of the University of Oxford, of Cambridge, of London, or of any other University in the United Kingdom; or that he has passed with Honours the Senior Local Examination of the University of Oxford or of Cambridge; or has obtained a Higher Certificate at the examination of the Oxford and Cambridge Schools Examination Board, he will be exempt from this preliminary. Entrance to this, however, is only allowed on proof (1) that the student is, or has been, a pupil of a surveyor; (2) that he is training with a view to entering the profession at one of the recognised agricultural colleges.

After he has been duly elected as a student, the next step that he should take is the qualifying Examination for the Class of Professional Associateship; and in this case the age at which he may sit must not be less than 21½ years. Of the three heads into which this examination is divided, one subdivision applies entirely to the estate (town) agent, and includes these subjects:

(1) Land Surveying and Levelling. Elements of Trigonometry.	(5) Mensuration.
	(6) Law of Fixtures.
	(7) Law of Dilapidations.
(2) Bookkeeping.	(8) Law of Easements and Riparian Rights.
(3) Law of Landlord and Tenant (Elements of).	(9) Application and use of Valuation Tables.
(4) Enfranchisement of Copyholds.	(10) Drainage and Sanitation.

In addition to the list of subjects given above, the student is required to prepare a plan to a given scale of a property of about twenty acres, showing a section of the levels, and taking the chief angles with a theodolite.

It may here be mentioned that it is not compulsory to become a student before entering for the Professional Associateship Examination, but a non-student will be required to gain a larger percentage of marks than if he had passed the preliminary examination.

The third stage is reached in the Fellowship, the subjects of which are practically those of the Associateship, but in a more advanced degree.

Copies of the revised syllabus of subjects, list of textbooks, and examples of papers set at preliminary and professional examinations can be obtained on application to the Secretary of the Surveyors' Institution, 12, Great George Street, Westminster, S.W., at the price of 1s. 6d. per copy.

As a considerable portion of an estate agent's time is expended on the details of properties placed under his charge, it is essential that a good practical knowledge of bookkeeping should be his particular care. He should be business-like not only as regards his own engagements, and so on, but in thoroughly recording the various transactions which may pass through his hands.

Estate Management. Estate management includes the collection of rents, the supervision of repairs, and, in fact, generally acting in the interests of the owner of the property, seeing that tenants' covenants are strictly adhered to, so that the reversion is not jeopardised.

The keeping of office registers of properties must be systematic, so that the smallest detail can be referred to without delay. Making and checking inventories require a good knowledge of technical terms in addition to a keen insight into present market values. Preparing schedules of dilapidations and wants of reparation also falls under the duties of an agent. Their settlement is a subject for negotiation between the freeholder and leaseholder, or between the original leaseholder and tenant.

It naturally involves a strict attention to the interests of whichever party the agent may be representing.

In taking particulars of properties for auction or registering purposes, it will not be sufficient to merely record the obvious facts; whoever draws up the particulars should have the faculty of showing to the best advantage any special feature which he may discern. He will not omit to enlarge on the advantages of aspect, soil, drainage, healthy situation, access, any local places of interest, and the attractions of the neighbourhood generally. In negotiating the sale or letting of properties a business-like agent will avail himself of all correspondence or applications that may have bearing on the particular subject in hand. He will exert all his influence to discover a purchaser or tenant, and not rely solely on haphazard inquiries. He will quickly find that success in this direction will act as the best advertisement for his agency.

LAND AGENCY

Following our assumption that the youth leaving school or college carries with him a fair commercial knowledge, we propose marking out his further studies with the profession of a land agent in view. Undoubtedly, the best connecting link between the general education acquired at school and the practical experience of an estate agent's office will be found in a short course at one of the recognised agricultural colleges, where technical knowledge and theory are acquired together. Here he will have opportunities of learning, by actual work under trained supervision, matters of essential importance both as regards the surface of the land, its chemistry and treatment, and the legal aspect of its holdings. He will thus be prepared to grasp intelligently the more complicated difficulties that may arise in daily practice during the period about to be spent in some estate agent's office.

The general routine of study adopted at the colleges naturally prepares the student for the examinations he will read and ultimately enter for. A general outline of the subjects will be enumerated later. The term of study varies in length, and is to a large extent determined by the amount of money at the disposal of the pupil, his parents or guardians; but we do not advise too lengthened a period, taking into consideration the subsequent years of pupilage to a land agent.

Training. Two years' training in this way should be sufficient. It is not our intention to imply that the preliminary training that we have outlined is essential to an estate agent, provided that such, or similar knowledge, could be gained from another source. For instance, it would be possible to learn the greater part of what is necessary on a well-managed farm where discipline was maintained, and where the student conscientiously made it his business to learn what was going on around him, if at the same time he added to an intimate insight into farming matters by judicious reading of works bearing on the legal aspect of his prospective career. So long as this knowledge is gained, it matters little what is its source.

This preparatory tuition having been obtained, the next step is the selection of a suitable office where the pupil may be indentured. It is advisable, where possible, that an agent should be chosen who has the management of estates in more than one county, as there is thus a more varied knowledge gained as regards the properties themselves, the requirements of their soils, their crops, or stock, and differences in local customs. The subject of the Articles themselves vary but little from those we have already noticed with regard to estate agency, but the period which they should cover may be altered to suit special requirements or circumstances. Taking into consideration the greater extent of the subjects with which the fully qualified agent must be conversant, it is natural that a longer time is covered either in the office itself, or in conjunction with the time spent at an agricultural college, or on a farm. For example, should two years have been devoted to this preliminary training, another two may be sufficient for a pupil's articles. If the training mentioned has been omitted, then quite three or four years will be necessary, and it therefore follows that the expense will be considerably greater in the case of a land agency pupil than with one who merely has an estate agency future in prospect.

As there are so many matters dependent on the individual arrangements of both pupil and master, it is difficult to give any definite idea as to the approximate amount of premium. It is largely a matter to be settled privately, but £100 per annum may be taken as a fair basis.

Examinations. The preparation for examination should occupy as great a portion as possible of the study of an estate agent. In the section dealing with town agency we have noted the advantages of as much spare time as office duties may permit being devoted to reading, and thus supplementing private study. Our remarks equally apply in this case. In fact, circumstances will, in all probability, give more latitude in this direction; but against this disadvantage must be set the inconvenience arising from the possible necessity for travelling considerable distances to attend lectures. The examinations we advise the would-be land agent to prepare for are those entered for by the estate agency candidates—viz., those of the Surveyor's Institute, and, as far as the Students' Examination is concerned, the same remarks apply. In the Intermediate or Professional Associateship, and Fellowship Examinations, a special subdivision is set apart dealing with subjects with which a land agent should be thoroughly conversant. The subjects included are these:

(1) Land Surveying and Levelling.
(2) Geology and Composition of Soils.
(3) Law of Landlord and Tenant.
(4) Agriculture.
(5) Land Drainage.
(6) Bookkeeping.
(7) Construction and arrangement of Farm Homesteads.
(8) Agricultural Chemistry.
(9) Trigonometry.

Special Knowledge Required. It is only possible to acquire thorough mastery of the requirements of a land agent's profession by a knowledge of the comparative methods of agriculture as applied to different countries; for it is obvious that there is a wide distinction between farming and farming pursuits as carried on in the Midlands and that in the northern and southern counties. The agent should know the differences demanded in the treatment of the soil, taking into consideration its productive qualities, whether applied to stock, crops, or minerals. For example, the special knowledge applicable to a district producing fruit would be comparatively useless in a mining district; and a county, the soil of which is chiefly given up to grazing, would naturally require relatively little knowledge with regard to to crops, but considerable experience in the handling of stock. And this experience should include not only the land itself but the buildings erected thereon for the purpose of housing or distributing the distinctive products. For guarding the interests of his superior, the agent will find this essential,

not only in the original leasing of land but in its after working or cultivation.

Having suggested the various directions in which his knowledge must be applied, and the manner in which it is determined by locality, it would be well, before leaving the subject, to glance at the general routine work as applied, more or less, to every estate office. Owing to the peculiar, and very often complicated, circumstances under which the properties are held, it will be at once seen that bookkeeping must play a more than ordinary part. Not only must records be kept of everything appertaining to the rent roll, but also of the considerable annual expenditure on repairs and improvements generally. Combined with these will be the ordinary everyday expenses, etc., in connection with any farms which he may have in hand, untenanted for the time being, but which must necessarily be kept in working order. It thus follows that his capacities as a farmer will be severely tested; and as questions such as the amount of compensation to be paid to an outgoing tenant for improvements, etc., under the various Agricultural Holdings Acts enter considerably into rental values, skill as a valuer is an essential qualification.

The Estate Agent and His Staff. Presuming that the preliminary training has been passed, and a profitable use made of the opportunities afforded by office work, we are now in a position to consider what should be done in starting business as a principal or acting partner. As we have already stated, the capital at disposal must necessarily exercise a considerable influence in this matter, as it is obviously less expensive in the long run to purchase a small partnership in a sound concern than to risk the disappointment and financial loss entailed in opening an office which may not, for reasons possibly outside personal control, be a success. Consideration must be taken of the fact that during the first months it is all uphill work, and that a man must be prepared to face the inevitable expenses without any compensating return. He must be prepared to take up the affairs of clients by means of assistants, to whom he will naturally have to pay salaries, and this in addition to rent, rates and taxes of the premises he occupies. Of course, if he is fortunate enough already to have an assured connection, these liabilities will be, to a large degree, lessened, and he may be thereby able to start his venture on a sound basis, adding to his staff as his clients increase. A good rent roll is the backbone of any business, and should be especially sought after and cultivated; for, owing to its reliability, it carries with it a certain assured income.

The least assistance possible is a clerk, with sufficient knowledge of the profession and business capabilities to take charge in his principal's absence, and a youth to fill in the minor office duties. In selecting the former, the choice should fall on a man willing and able to make himself generally useful in all departments, who is also a good canvasser—in short, one in whom confidence could be placed. As the agent's business develops, and the necessity for an increased staff arises, he will find it advisable to engage a junior, competent to relieve the senior clerk of most of the out-door duties, such as those of rent collecting, minor inventories, and canvassing, leaving the former with more time to devote to the necessary correspondence, interviewing, and negotiations. For this position, it is quite possible that he may find what may be termed an "improver"—that is, one who is endeavouring to enlarge his experience after having served his articles elsewhere. At this stage, also, he may have a sufficiently large practice to justify his taking an articled pupil.

Setting up in Business. The capital necessary to start business on one's own account will, to a large extent, depend on the locality selected, and the personal expenses of the agent. If he proposes to begin as an estate agent in town, the sum of £200 or £300 should be sufficient to cover the first year's expenses. As he has the advantage of being able to advertise—a privilege denied nearly all other professions—he has the means of procuring the introduction of business which, by perseverance and application, should steadily increase.

The land agent, on the other hand, must be able to dispose of a larger capital at first, as he, unlike the town agent, has not the facilities for advertising, and to a large extent must rely on business being brought to him. Although the results, when they do come, are better, one frequently has to wait a long time for them. We should, therefore, not advise any smaller sum than £500 in reserve for starting in this way.

The duties of the land agent are so much more personal in their nature than the estate agent's that more depends on his individual efforts, and, there being less of what may be termed clerical work involved, the office requirements are smaller. Here, again, the number of assistants will be determined by the extent of the estates under his control, their area, and the distance separating them. With a comparatively small radius, he will be able to exercise his duties fully without calling in professional aid; but where distance will prevent his giving equal attention in all directions, a sub-agent is generally engaged who is qualified to deal with minor matters as they may arise, referring to the principal agent where important decisions have to be made. The appointment of this official may rest with the agent himself, or he may be engaged by the landlord direct. In either case, although he is the agent's subordinate, he will usually receive his stipend from the owner of the property.

In the control of a farm a bailiff is usually employed. His duties may be likened to those of a foreman, his knowledge being purely practical, and his work confined to the particular farm upon which he is engaged. He sees that all operations on this farm are properly carried out; he is referred to as required, and gives instructions to the various farm "hands" as to what is necessary. He reports in detail to the agent, and receives from him whatever orders have to be given.

Foresters. On most estates of any considerable extent at least a portion of the property will be composed of woodlands, requiring the expert attention of a branch of skilled labourers, known as foresters, whose duties are periodically to prune and otherwise cultivate trees and undergrowths for timber purposes, or as game preserves.

We see, therefore, the reason for the estate agent being acquainted with this subject—so that he may properly direct and supervise work of this description. It is a matter of importance to know exactly how, and at what time, such work should be done that the best results may be obtained, and an eye given to the prospects of the future.

LAND AND ESTATE AGENCY *concluded; followed by* MEDICINE

Group 28
TEXTILES
37
Continued from page 5126

HOW TWINE & ROPE ARE MADE

Winding, Twisting, Cabling, Laying, Dressing, and Balling Twines. Rope Spinning and Finishing

By W. S. MURPHY

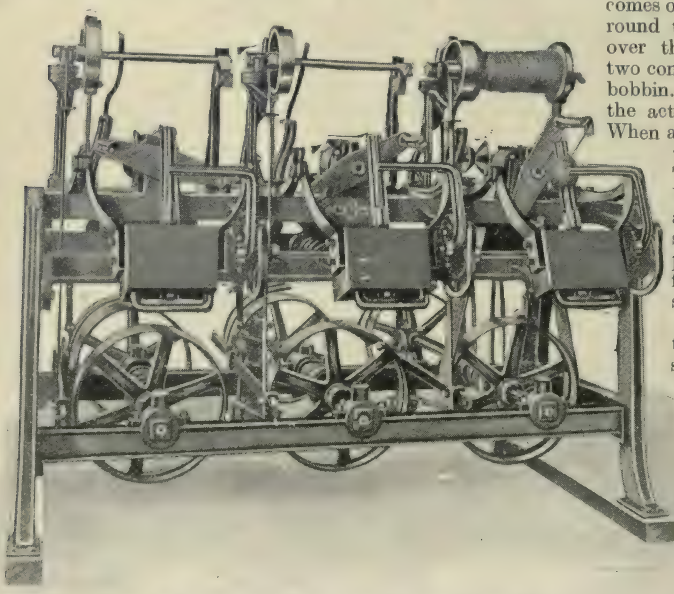
THOUGH we have studied the making of yarns for twines and ropes, such as flax, hemp, and jute, there are some kinds of yarns used by the twine and rope manufacturer which he must accept from other workers. The variety of material out of which cords and cables may be made is very wide, including cotton, silks, wool, mohair, horsehair, many kinds of vegetable fibres not yet otherwise recognised as textile, and iron, steel, brass, copper, and many other materials mostly wastes from other industries. As a rule, the rope and twine manufacturer spins his own flax and hemp yarns, accepting from other makers, or spinners, whatever other yarns he requires. At this point, therefore, we begin with the processes in which we utilise yarns, both those spun on the premises and those brought in from outside.

Winding. Some manufacturers buy in their yarns—and all must take those yarns which are not in the direct line of their work, such as cottons, wools, silks, and artificial fibres—from the outside. Those yarns come in hanks, and require to be wound on bobbins. Any common winding reel will serve this purpose, and we should hardly have thought of paying any attention to this detail but for the fact that associated with this operation we have a very useful machine and an operation which is of much service for the higher kinds of yarns. The machine is called a *doubling winder*. There are several forms of this machine in use; but in general the form is a double frame, with the hank wheel, or the bobbin creel and guide on one side, and on the other side the receiving bobbins and guides with stop motion. Possessed of this form of machine, the twine or cord maker can deal with any kind of yarn in any form.

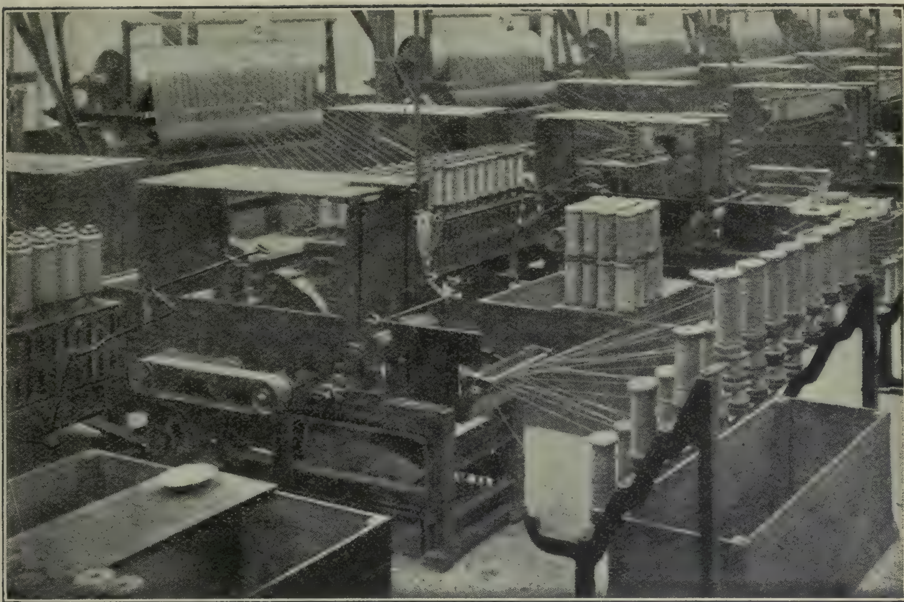
Twisting. Though the yarns may have been doubled, they are yet without that twist which gives them cohesion. Being very simple, and similar in principle to many other textile machines, the twine manufacturer has a large choice in this class of machines. But the whole range can be divided into two classes—one called the *upward twister*, and the other the *tube twister*, or any other kind of common textile twisting machine.

Upward Twister. In spinning, the feed bobbins stand on a creel at the head of the frame, and the receiving bobbins sit on the rails in the middle of the structure. In this machine the positions are reversed. Flyers with three legs work on the spindles which hold the supply bobbins, coming up from the lower end of the bobbin. Midway is a carrier rail for the yarn; above it two grooved cone pulleys; and on the top the creel of receiving bobbins. As the yarn comes off the bobbin, it is passed round the legs of the flyer, up over the carrier rail, round the two cone pulleys, and on to the bobbin. A special feature is the action of the two pulleys. When a fibre is twisted it tends to shorten and curl up. The second cone pulley, being wider than the first, and receiving exactly the same amount of yarn, pulls the cord tight, confirming the twist and straightening out the line.

Tube Twister. As the name implies, the special feature of this machine is its twisting tube. In other respects it differs little, if anything, from the ordinary frames used in the spinning factories. By the gentle and efficient action of the tube this frame has been found very useful by twisters of



235. M'CORMICK TWINE-BALLING MACHINE



236. TWINE DRESSING (Belfast Rope Co.)

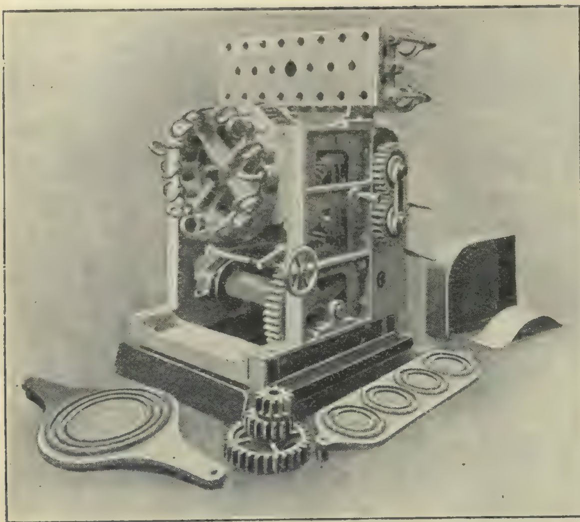
silks and fine cords of all kinds. Sewing machinery, which has become so important in the shoemaking, saddlery, and other leather-working trades, has created a strong demand for the twist made by this machine. It produces a smooth and compact thread.

Cabling Twines. The common twine of commerce is the three-cord cable twine. An extraordinary twisting frame of large size is very often used for this purpose; but the produce is soft and of a low class as a rule. We do not say that a modification of the twister cannot produce good twine; but we think that machines specially designed for the purpose are more likely to prove satisfactory. Among the many to select from we take two, one being quite a departure from the twisting frame, and the other an adaptation of the upward twister.

A Double Cabling Frame. This frame is simply the upward twisting frame with the addition of a cabling side. On this side the three rows of bobbins are placed, with flyers coming up from the base of the bobbins. Above are the two cone pulleys and a guide rail. But in the centre of the double-sided frame are two guides and a collecting tube, while at the other side we find another pair of cone pulleys, and down on the side of the frame a large bobbin upon the spindle of which works a powerful flyer. Coming from the three bobbins, the yarns, or strands, are twisted, led through the small and large cone, and therefore stretched, joined together on the head of the frame, twisted through the pair of cone pulleys on the other side, taken through the head of the powerful flyer, and wound on to the large bobbin. Fishing lines, loom cords, spindle bandings, and high-class twines of all kinds are efficiently formed on this frame.

Laying Machine. For directness of action, the "Patent Laying Machine," as it is named, is certainly very good. From a plate across the head the spindles, containing the bobbins hung horizontally, depend, the bobbins being driven by bands on spindle whorls. Directly under are the guides and twisting gear, while below all rest the receiving bobbins, on the spindles of which revolve large flyers. Twines can be twisted with great rapidity on this machine. Any thickness, from two to six cord, is dealt with, and bobbins of large diameter filled.

Dressing. After the twines have been twisted, the finer qualities of hemp and flax cords are gassed, or singed, by any of the gassing appliances examined in the finishing processes of threads and cloths. Then the twines are dressed—that is, passed through a bath of size—and polished. Some manufacturers omit this process. We think it wise to dress twines, however, not only because the dressing helps to give the strands a closer tenacity, but also for the sake of appearance, which counts for so much in commerce in these days. The size is a thin paste, made of flour, glue, alum, and tallow, in the proportions which experience shows may best suit the particular quality of twine being made. In general, heavy twines are the better of a fair proportion of tallow and alum; for finer twines the alum may be omitted. The dressing and polishing machine [236] is a large piece of mechanism. At one end are the creels, which hold the bobbins of twine; next is the guiding reed, or raddle; next is the steam-heated trough containing



237. FOREBOARD, REGISTER PLATES AND CHANGE WHEELS
(Combe, Barbour & Co., Belfast)

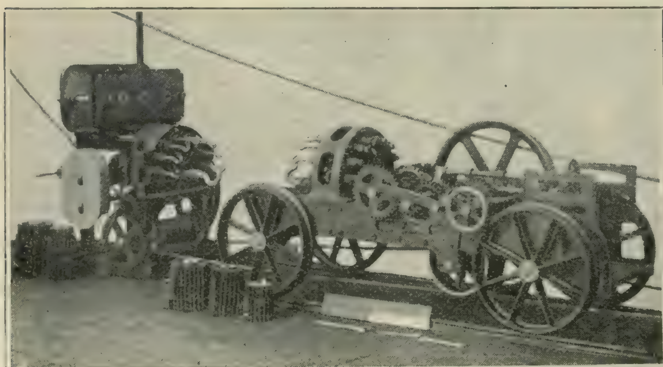
the size; within the trough revolve the dipping rollers; at the further end of the trough, the clearing rollers, a little above, the first brush rollers; next, the drying cylinders; last, the polishing rollers. The twines pass through the guide down into the size, over the one roller and up on the other; here they pass through the clearing rollers, which sluice off the superfluous size, and go through the brush rollers, which partially dry them. Winding helically round the steam-heated drying rollers, the cords pass between the polishing rollers, and are again wound on to bobbins.

Balling and Spooling. Twine is either made up into balls without any core, or wound into a kind of cheese shape, which may have a wooden core or none. Several very ingenious machines have been invented for both these purposes. The cheese winders are merely larger models of the frames used in thread manufacture, studied fully in that section of our course. We therefore omit them at present. The balling machine, however, is new. Two kinds are worthy of special note, and we shall take them in succession.

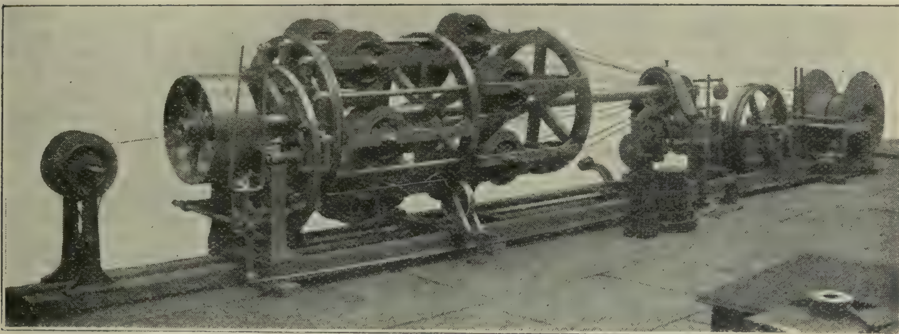
Flyer Balling Machine. The bobbin is fixed on a spindle at one side; in a plate or standard, the flyer is set to revolve in a reciprocating manner over a spindle coming out from a wheel axle on the other side. The twine is given off from the bobbin, and is taken by the flyers and wound on the thick spindle. There are usually two pairs of balls wound on this frame.

M'Cormick's Machine. This machine [235] is generally admitted to be one of the best automatic balling apparatus in the trade. All the parts are very strong. The feed bobbin is hung horizontally on the head of the machine, and the twine is led through the eye of a lever with an eccentric motion, which winds the twine on to the balling spindle set before it. A guide arm keeps the ball firm and regulates the shaping and consistency of the ball. When the required quantity has been wound, the machine stops.

Theory of Rope Spinning. On page 1028 we gave only a hint of the principle upon which rope-making is based. The long, heavy fibres of which most ropes are made do not naturally cling together in a spiral form; on the contrary, they resist being put into that form. It is because the fibres resist twining that ropes cohere. This contradiction, or paradox, must be made clear, and can best be shown by a practical illustration. Suppose we undertake to make a cable about 6 in. thick. First, we take 30 yarns which have been twisted from left to right, and twist them together into a strand by a right to left twist; the effort of the individual yarns to untwist will pull from right to left, and cause them to grip more tightly together in the twist the stranding has given them. Every effort those little fibres make to free themselves from each other binds them more tightly in the larger unity. Nine of those strands have been made, and we now reduce their number to three by combining three strands together. Again we twist from left to right, and the effort of the smaller strands to untwist being in the same direction, they confirm the grip of the last twist. Finally, when we twist the three large strands into a cable, by a right to left twist, we enlist the tendency of every single fibre to untwist in binding our whole cable together.



238. FOREBOARD AND TRAVELLER (Thomas Barraclough, London)



239. HORIZONTAL STRANDING MACHINE (Thomas Barraclough, London)

If we try to break up a cable by loosening the strands and threads, we have against us the natural effort of the fibres to free themselves.

Two Methods. Rope-spinning has taken two forms—the factory method and the rope-walk. The latter is the old hand method to which machinery has been applied. The factory method consists in the application of the twisting of textile fibres to be seen in all factories, but on a gigantic scale, and with machines correspondingly large. The rope-walk, as the oldest, and, in the opinion of many, the better, may be studied first.

Rope-walk. A rope-walk may be any length, from 70 to 300 yards. It is a long, covered-in shed, laid with a series of rails along which run the spinning machines which have displaced the human rope-spinner—in this country, at least.

Creel. A V-shaped board, bearing as many as, perhaps, from 270 to 333 spindles for holding bobbins, is placed at the head of the walk. It is from this that the rope yarns are drawn.

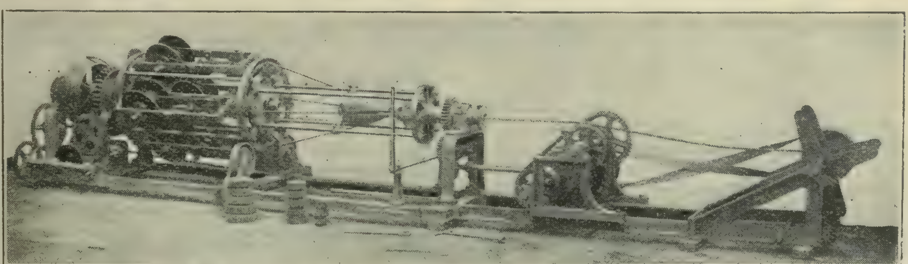
Register Grid and Plate. Before the creel stands what is called the *register.* This is a frame containing iron rods, forming little squares, with a plate in front of it, into which several series of concentric holes are drilled. From the creel the yarns are led through both grid and register plate. The latter may have nine concentric holes in a circle of eight, with one in the centre, or nine circles, each containing 27 holes, or any multiple of three or nine, according to the size of rope to be made.

Foreboard. Further in we find a heavy carriage [237], sitting on the head of which is a square box, with tubes running through it, and on the breast of the machine a set of large hooks. The box is the steam chest, kept constantly heated by a steam pipe, and the tubes are the passages in which the yarns are gathered, and through which they pass to become strands. The hooks in front are set in a circle round one large hook. On these the strands are linked when made, to be twisted together again into thicker strands.

Traveller. Two lines of rails run from the front of the foreboard, and away down the rope-walk. Upon these rails stands what we call the traveller [238]. This is almost an exact counterpart of the fore turn, without the steam chest, and it is set on wheels which run on the rails of the rope-walk. The hooks of both foreboard and traveller are fixed on spindles, which are made to revolve by means of wheels driven by the rope pulley at the side of each machine. These wheels are change-wheels, the size being according to the speed of revolution required. By means of clutch gearing, the revolution of the hooks can be reversed. Upon the traveller are strong brakes for controlling its speed, and a platform for the workmen.

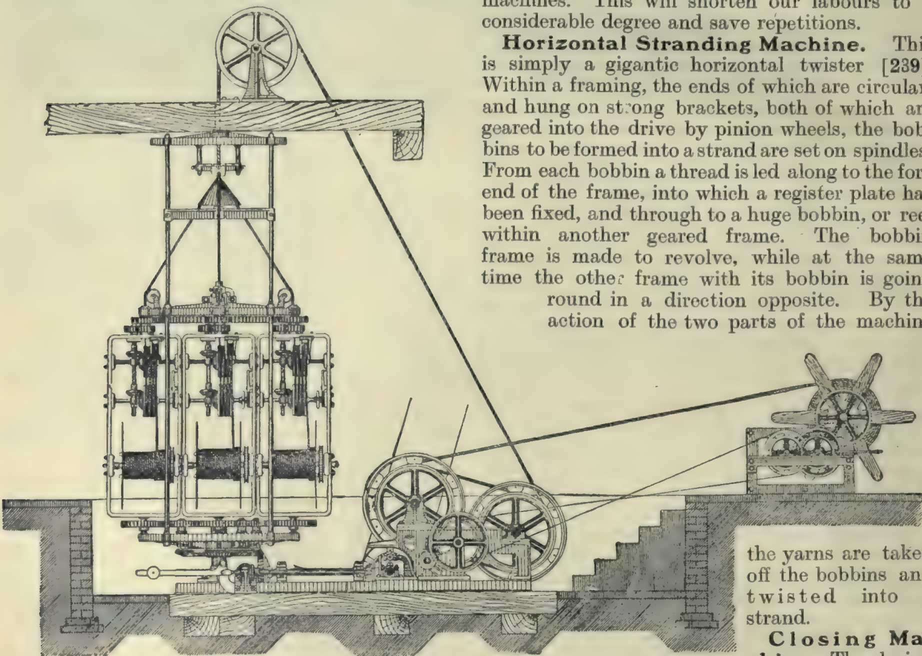
Gates and Posts. To complete the furnishing of the rope-walk we require gates and posts. These are the rests upon which the long lengths of strands or ropes are supported as they are being formed. The gates close behind the traveller as it comes along the walk, and the posts stand beside the walk with forked heads, into which the rope may be laid.

Making the Rope. The yarn bobbins are set on the creel, and led through the grid and register plate in sections. The bunches are



240. SMALL WIRE ROPE MACHINE (Thomas Barraclough, London)

gathered in the strand tube, and are tied on to nine hooks on the breast of the traveller. Away goes the traveller down the walk, drawing out the yarns to the full length. When the traveller has reached the end of its journey the yarns are cut and tied on to the hooks of the foreboard. As the traveller passes down, the gates close after it, supporting the formed strands. These have been twisted from right to left. When thus twisted the ends are transferred to the hooks on the foreboard, and between them the traveller and foreboard form the strands into three, by a left to right twist. Now comes the final operation—the laying of the cable. A bight is formed on the ends of the strands joined into one, and this is linked on to the centre hook of the traveller. What is called a *top*, a block of wood mounted on a bogie, is brought close up to the traveller. The hooks on the foreboard keep turning to maintain the former twist on the strands, while the traveller powerfully twists the strands into one, driving the top before the twist. By its weight, assisted by the powerful brakes, the traveller prevents the rope from curling up under the strong pull of the twist. When the cable has been laid it is wound by powerful winches on to a coiling drum.



241. CLOSING MACHINE (Thomas Barraclough, London)

Other Ropes. We have viewed a cable being made in one operation; but that is very seldom done. The strands are often made one by one. Then there are hawsers, made of three thick strands separately laid, besides thinner ropes, generally composed of three strands, of from two to six strands each.

Tarring Ropes. Most cables and hawsers are made up of tarred strands. These are run through a tarring machine, closely resembling a twine-dressing machine in principle. After the tar has been put on, the strands are allowed to mellow for some time.

Factory Rope-laying Machines. It is undoubtedly owing to the invention of this class of machines that the wire rope business has been developed. In studying the process, therefore, we have to keep in mind that wires, as well as fibrous yarns, may be on the machines. This will shorten our labours to a considerable degree and save repetitions.

Horizontal Stranding Machine. This is simply a gigantic horizontal twister [239]. Within a framing, the ends of which are circular, and hung on strong brackets, both of which are geared into the drive by pinion wheels, the bobbins to be formed into a strand are set on spindles. From each bobbin a thread is led along to the fore end of the frame, into which a register plate has been fixed, and through to a huge bobbin, or reel within another geared frame. The bobbin frame is made to revolve, while at the same time the other frame with its bobbin is going round in a direction opposite. By the action of the two parts of the machine the yarns are taken off the bobbins and twisted into a strand.

Closing Machine. The closing machine [241] is simpler than its stranding assistant, but somewhat different in structure. The bobbins are fixed in a frame upon spindles which have a revolution of their own while carried round by the containing frame.

Through a plate in the head of the frame the strands are drawn into the closing tube, through tempering apparatus, and out on to the creel, or barrel, which, by differential gearing, is enabled to take on the rope evenly as it fills.

A Small Machine. Thin wire ropes are made on this machine [240]. First the wires are made into strands, by being placed within frames which have a flying motion. Between this frame and the laying apparatus is a stretching appliance, composed of coned rolls, one large and one small, the strands passing round both to be stretched and straightened. The whole framing next revolves, and, as the strands, three, or four, or five, come into the central twister, they become united.

Continued

JOINERY

Panelled Work. Counter and Table Tops. Cases. Methods of Construction and of Working. Curved Work. Staircases and Handrailing

Continued from page 5187

By WILLIAM J. HORNER

HAVING dealt with doors and windows, which, with staircases to follow, constitute the main work in joinery, we now have a large variety of other work which it is neither possible nor necessary to take in detail. In the interior fittings of shops, public buildings, ships, railway cars, and in the construction of plain furniture, and numerous other articles of wood, there is too much to attempt to take individually. Instead, therefore, of giving full details of a few specific constructions, which would involve more or less repetition, we will turn attention to principles, and to details which vary.

Panelled Frames. Large panelled surfaces are often required for partitions, counter fronts, screens, backs of bookcases, show-cases, and articles of furniture. They may consist either of one frame of the size required, or of separate ones secured edge to edge. The tenoning of rails, stiles, and muntins, and the grooving for panels is identical in all cases, and has already been described; but the arrangement varies with circumstances. A large frame in which a number of rails and muntins cross is more troublesome to make and weaker than a number of narrow frames employed to cover the same area. The latter, therefore, are generally preferred where circumstances permit. In many cases their connection to the other portions of the structure is sufficient to keep them in position in relation to each other, as when attached to the back of a large bookcase or to the floor and ceiling at bottom and top. The joints between them are usually tongued and beaded, unless covered by other parts. When the panelled work stands alone, as in the case of a screen, the top may be grooved for a strip of iron, which keeps the parts in line and holds them together, as in **103**. Or a continuous capping piece alone may serve the same purpose.

Joints are concealed as far as possible by carrying them along the quirks of beads, as shown. Handrail bolts or screws may also be employed to hold the parts together. Rods may be carried up at intervals to keep a screen upright, and brackets attached to the floor, but these latter are employed only when no better means are possible.

Fig. **104** shows a form of joint often employed for the muntins in counter fronts instead of a mortise and tenon. The top and bottom rails are thus continuous, while the muntins are carried through on the outside.

Counter and Table Tops. Except in very rough work these are secured so that some lateral freedom is allowed for the shrinking and swelling that is unavoidable in great widths. The usual method is by means of *buttons*. Fig. **105** is a view of the under surface of a table top showing how it is held to the frame by buttons. They are screwed to the under surface of the top and fit into grooves in the end rails, and sometimes clip over a rebate on the edge of the cross bars which are fitted to intermediate parts of the frame. Another method of allowing lateral adjustment to wide pieces is to screw them, but to cut slotted holes for the heads of the screws. This is often done in attaching cleats to drawing boards. Tops usually have to be glued up to the required width, preferably with tongued or dowelled joints.

End joints in counter tops are often pulled together by the arrangement shown in **106**. Three strips are secured to the under surface, as shown; two of them on one of the portions to be joined, and one of them on the other, with about half their lengths overlapping, so that when the parts are together the single one fits between the other two. Slots are cut in them, arranged so that folding wedges driven through pull the parts tightly together. The unattached ends of the strips are then screwed to the surface also. The joint may also be tongued.

Thickening Up of Edges. Table and counter tops are usually thickened, as shown in **107** to **109**, by attaching narrow pieces to their under edges. This improves the appearance and slightly adds to the strength. There is seldom any necessity to have a top more than 1 in. thick, but they are thickened at the edges to appear from twice to three or four times that amount. Fig. **108** is a plan view of the under face of **107**, showing that the grain of the thickening pieces should run with the grain of the top. If the piece across the end had its grain transversely, shrinkage of the top would break the glue joint, and if it was screwed instead, there would be a risk of the top splitting. But in addition to this, the main purpose of thickening is to make the top appear thick, and this effect would be lost if an end did not show end grain throughout. Fig. **110** shows a more elaborate method of thickening up the front of a counter top, and of supporting the overhang by brackets or trusses against the front frame.

Cases. Glazed show-cases are generally required to be dust-proof, and consequently airtight. This is accomplished by intricate joints in which rebates, tongues, and beads, fitting into corresponding grooves, are freely used. Velvet and rubber are sometimes inserted to ensure a close joint between surfaces. Glass is often bedded on some such material to lessen risk of its getting jarred or strained by warping of the wood. In many instances also, the joints must be elaborately made, to ensure as strong a union as possible between slender rails, posts, and bars, which are rebated to receive glass. They often appear as a plain mitre joint on the exterior, but are generally a pair of secret dovetails or a pair of thin tenons, arranged according to the shape of the parts.

Plinths and Cornices. In joinery, these terms apply to projecting moulding attached to the bottom and top edges of articles. The moulding at the base is called a *plinth*, and that at the top, a *cornice*. A cornice is purely ornamental. A plinth is, in many cases, necessary to protect more delicate parts of the base from injury, or to raise them to a convenient height. Figs. **111** to **117** show examples of plinths and methods of attaching them, and **118** to **120** show cornices. A plinth has to carry, or assist in carrying, the weight of the structure above, and therefore should be substantial and

properly attached. It may be either attached to the sides or placed beneath. In the first case it either merely thickens up the lower portion, as in the box shown in **111**, or is screwed to a skeleton base formed by projecting horns of stiles. This might be the case in **112**, but is shown distinctly, though in rather complex form, in **117**. In **113**, the plinth is a deep framework on which the upper structure rests. In such cases, the two parts are usually not attached, but one merely rests on the other, and they are kept in lateral position by blocks, which are screwed to the under surface of the upper part, and fit within the framed plinth. This is done in heavy articles of furniture so that they can be conveniently moved in parts. Cornices are sometimes put on similarly. In **114** the block beneath is supposed to be carried entirely round the base. It would be a very satisfactory alternative method of treating the box shown in **111**. In **115** the plinth is rebated, and is held in place by blocks glued into the interior angle. Fig. **116** shows a plinth beneath, with the bottom board tongued into it.

Cornices are attached in any convenient manner, being screwed either to top or side, or held by blocks glued in the angle. Fig. **118** shows the usual method of attaching a cornice to bookcases and wardrobes. The moulding is wide and thin, and has its edge bevelled so that when screwed on the upper surface, its front slopes outward, as shown. Sometimes glue blocks are fitted in the interior angles. To cut the ends of the mouldings to the correct angle for the joints, the moulding must be tilted in the mitre-box to its proper position, and the sawcut may then be made in the usual way. Figs. **119** and **120** show cornice moulding attached to the front.

Blocking and Screwing. Wood blocks, glued into interior angles to unite parts, as shown in **121**, A and B, are very commonly used in joinery and cabinet work. They are shown in **121** joining two pieces at a right angle, but they may, of course, be planed to fit any angle. At A the block is square in section, and at B triangular; but the outward shape is usually of no importance, as they are used in places where, under ordinary circumstances, they will be out of sight in the finished work. The alternative to the blocks is to use screws, as shown in **122** at A and B, and in end view in **123**. When there is no objection to a hole in the outer edge, the most direct method is to put the screw in as shown at A in **122** and **123**. The other method is to insert it at an angle through the side, gouging ou sufficient room for the head to go down, as at B. These methods are practised solely to avoid putting screws or nails through from the front of the work, where their appearance would be objectionable. Otherwise, in the examples shown, screws put through from the other side would be decidedly better and stronger.

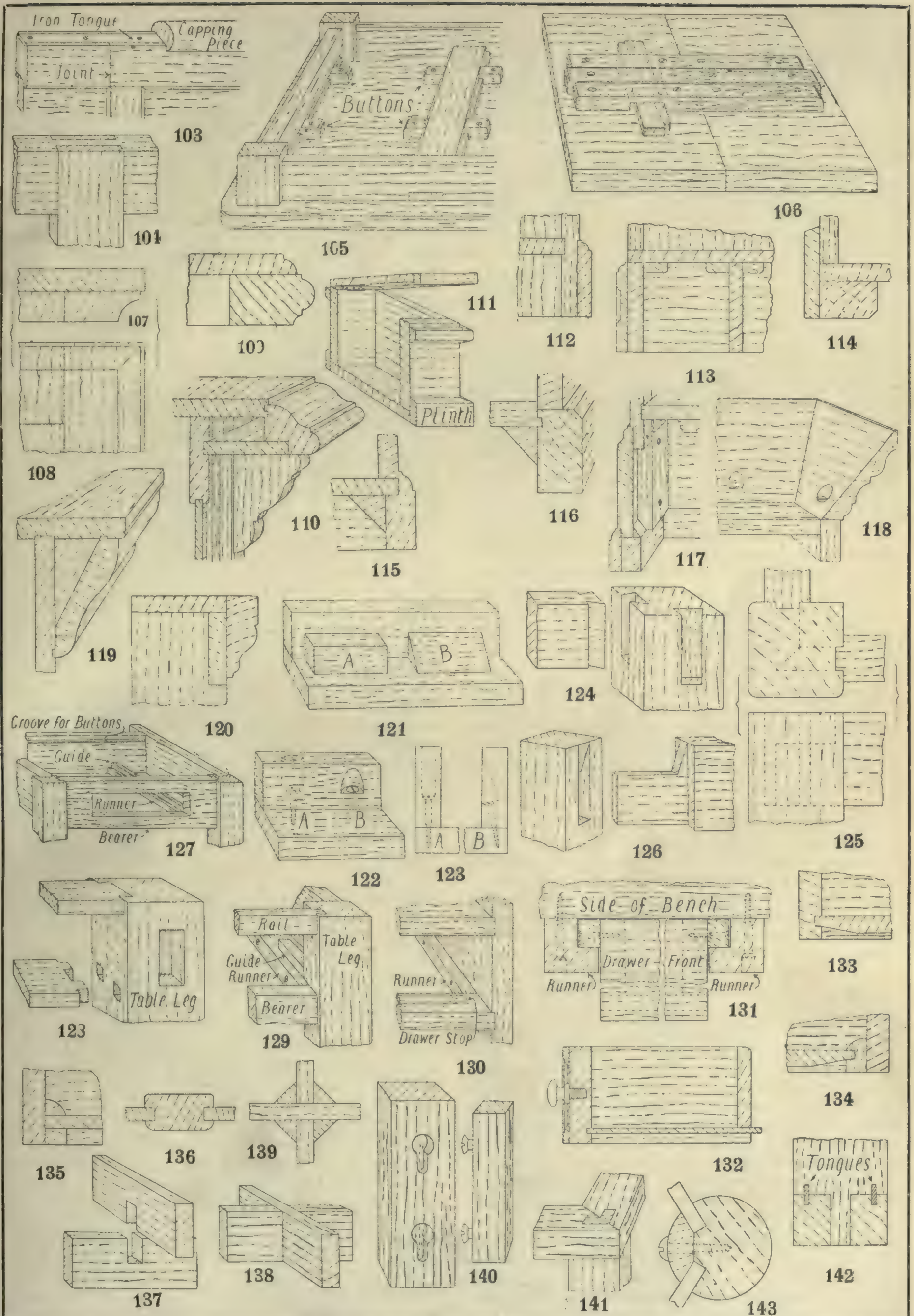
Frames for Plain Tables. These consist of legs held together by rails which are tenoned or dovetailed into the tops of the legs. Where extra stability is required, rails are also fitted between the lower parts, but this is avoided if possible. The method of dovetailing is shown in **124**. Tenons are shown in plan and elevation in **125**. In the example shown they meet with ends mitred, but in some cases they could be shorter. The upper part is haunched. Fig. **126** is another form of haunch which was not shown in Carpentry. A haunch cut in that way is not visible when the parts are together. In the frame of a table the parallel haunch in **125** is quite satisfactory because it is covered when the top is on.

When the table is of considerable length, or when the ends of drawer runners require support, one or more intermediate cross rails are inserted. Examples of these are shown in **105** and **127**. In the latter figure the front rail is shown cut to receive a drawer, but a better method is to fit separate rails above and below, as in **128**.

Runners for Drawers. The runners can then be screwed or nailed against the inside faces of the longitudinal rails, as in **129**. Runners form ledges on which a drawer rests and slides. When the part beneath a drawer is closed in by a dust board the drawer slides on this, and runners are not necessary. Besides surfaces to slide on, drawers require guides at the sides, and a stop of some kind to stop them at the correct position when being closed. In a construction like **130**, the sides of the article act as guides for the drawer, but in tables it is generally necessary either to rebate the runners, as in **127** and **131**, or nail guide strips on, as in **129**. The drawer shown in **131** differs from the previous examples in having the runners at the top and strips screwed to its upper edges to fit them. This is done because it is more convenient to screw runners to the under edges of the bench than to box the drawer in to enable it to rest on its bottom. Another method, suitable for cases containing a large number of shallow drawers, is to arrange the runners about midway in the drawer depth and to groove the drawer sides to fit them. The drawers then can be close together without bars between. When closed to the proper extent a drawer may be stopped either by a rail at the back or by blocks on the runner, or at the front by a thin strip, as in **130**, which stops the drawer front, but allows the raised bottom to pass over it.

Drawers. A longitudinal section through a drawer is given in **132** to show the ordinary arrangement of the parts. The bottom is thin, and usually chamfered down at the edges to fit in grooves which are ploughed in the front and sides. The back is reduced in depth, so that the bottom can be slid in after the front, sides, and back are framed together. Another reason for this is that the bottom can then be allowed to extend a little beyond the back, thus allowing ample for shrinkage. The bottom may be prevented from coming out of place by putting a screw through it into the drawer back. It will then shrink back from the front, and if in time it comes out of the front groove, the screw may be taken out and the bottom pushed forward and re-screwed. A portion of an end view of a drawer is shown in **133**, where the bottom fitting in its groove in the side is viewed from the back of the drawer. Figs. **134** and **135** show other methods of fitting the bottom without grooving the sides; **136** is a muntin across the middle of the bottom of a very wide drawer, the bottom then being divided into two panels. The grain of a bottom should always run across parallel with front and back, so that shrinkage can be allowed for as just described. In a rough drawer like **131** the bottom is nailed on. The sides, front, and back of a drawer may be either dovetailed or nailed together, according to the quality of the work. When dovetailed they are glued, and usually not nailed as well. Fronts are nearly always lap dovetailed, and are then thicker than the sides and back.

Miscellaneous Work. Deep pieces which cross each other, as in partitions in boxes and drawers and many other articles, may be halved, as in **137**, and appear when together as in **138**. This is generally the strongest and simplest method, but when there is any reason why one of the members



JOINERY

103. Joint in panelled frame 104. Forked tenon 105. A table top buttoned to its frame 106. Joint drawn together by wedges 10 -109. Thickened edges 110. Counter top 111-117. Examples of plinths 118-120. Cornices 121. Glue blocks 122 and 123. Concealed screws 124. Rail dovetailed into table leg 125. Rails tenoned into table leg 126. Haunched tenon 127. Runner supported at back by rail 128. Rails for drawer 129. Guides and runners for drawer 130. Another arrangement for a drawer 131. Bench drawer 132. Section through a drawer. 133-136. Details of drawers 137 and 138. Example of halving 139. Blocks in corners 140. Secret fixing 141. Box tenon 142. Tongues in a wide tenoned joint 143. Method of holding glass in a rebate

should not have its strength diminished in this way, it may be carried through entire, and the other fitted and secured in any convenient way on each side. Sometimes the cut piece may have its ends housed or veed into the other, or blocks may be glued in the corners, as in **139**.

When parts of highly finished work have to be attached without showing any exterior sign of the means of connection, and where a glued joint is unsuitable, the method shown in **140** is adopted. Screws are inserted in one piece with their heads left about ½ in. above the surface, and slots are cut in the other to correspond. The slot is made large enough at one end to receive the head of the screw, and the remainder of its length fits the shank or body of the screw. The parts are put together with the heads inserted in the large holes, and they are then forced along the slots, the heads cutting their own way and keeping the parts together. The slots should be arranged so that the parts are in correct position when the screws have been forced nearly or quite to the ends. Either mallet blows or pressure may be employed, and care should be taken to keep the parts in close contact while it is being done. The slots should always run with the grain. The parts can be separated by knocking back again. When in a vertical position, the direction for fixing should be downwards.

Figure **141** shows a form of tenon sometimes used at mitred corners of frames. Fig. **142** shows how a wide member with a single tenon may be prevented from tendency to twist, by inserting tongues; **143** shows the usual method of securing glass in the bars of shop-fronts and cases.

Curved Work. Curved surfaces are formed by bending, by working out of solid wood of sufficient bulk, or by building up a number of pieces arranged according to the contour desired, and then working the whole to shape. The last method is in most cases the best, and often is the only practicable one, but circumstances always decide.

Pieces of wood that are sufficiently thin in proportion to their length can be bent considerably without fracture. If the bending process is applied gradually, and especially if the wood is first soaked in hot water, or preferably steamed, this amount is very much further increased. If, after steaming, the wood is secured till it is dry against a block formed to the required curvature, it will retain its curved form when released. The amount to which wood can be bent depends on its section, and on the kind of wood. Bending is nearly always practised lengthwise, and not across the fibres, for in width and thickness, material can easily be glued up and planed to any curvature. In many cases wood can be bent without special appliances, simply by screwing it in place, and so forcing it to accommodate itself to the sweep of the surface to which it is screwed. Or it will form a sweep of its own if it be bent and the ends immovably secured. When a number of pieces of similar curvature have to be bent, a suitable appliance is made. These appliances vary in form considerably, but the essentials are a surface of the required curve and means for gradually forcing the wood to that curve and keeping it there for several hours.

In rough work a common method is to weaken the wood by running saw-cuts across, as in **144**. This can usually be employed only in cases where the saw-cuts will be concealed, and therefore the uncut face of the wood should always be outwards, and the other against another surface. The cuts should be uniform in depth and distance apart, and spaced rather closely, but the outer face always shows more or less sign of a series of flats corresponding with the spacing of the saw-cuts. Figs. **145** and **146** show the piece bent to opposite sweeps.

Building Up. Figures **147** to **157** show various methods of building up; **147** and **148** are examples of plain circular plates. In **147** a number of boards are joined edge to edge to form the required diameter, and the whole is kept straight by battens. Instead of battens, two thicknesses of wood may be employed with grain crossed. Shrinkage in the first case results in the circle becoming more or less elliptic, and in the second in overlapping edges. In **148**, a plate is built up in a way that obviates diametral shrinkage, but at some sacrifice of strength. Two thicknesses are necessary, so that the segments may break joint. It is adopted chiefly in pattern-making, when the pattern is of a character that requires rims similar to **149** on one or both faces of the plate; **149** is a ring built in segments. In small rings the number of segments to a layer is usually six, and in large ones more. The end grain joints overlap in the layers as shown, and therefore, no matter how shallow the ring, there should be at least two layers or thicknesses, and preferably not less than three. Rings like this are usually turned in the lathe, but not necessarily so. One segment is marked out and sawn, and used as a templet to mark the others from. They are sawn roughly to shape, and the faces and ends fitted by planing them on a shooting board. They are glued and usually bradded as well. Where comparatively deep segments are employed, as in **150**, the end grain joints are often splayed and tongued, as shown. Fig. **151** shows narrow boards tongued edge to edge to form a curve, the edge joints being bevelled to the required inclination; **152** shows another method of forming curved work too large or too wasteful of material to be cut from one piece; **153** shows pieces halved together at a suitable angle to form a required curve; **154** is an example of staving up to form a cylinder or curved surface too large for solid wood.

Splayed Work. The heads and sides of windows and doorways are sometimes splayed, and also the sides and ends of hoppers and other constructions. Some marking out is necessary to obtain the angles at the joints; **155**, A, B, C, shows three views of a splayed construction, in which the angles of the sides in B are not the same as those of the top in A and C. The edges also are on one side bevelled and on the other square with the faces of the wood. The face view at A does not give the actual angles of the joints because the parts are viewed in an inclined position. The angles to cut the pieces to must be obtained by laying them out flat, as shown by the dotted lines on the left-hand side in A. The width of the inner face, 1 to 2, in B, is taken and transferred to A by adding the dotted line 1 at a corresponding distance from the inner edge 2. The actual length of each edge is already correctly given in A, and therefore the length of the outer edge is projected to the dotted line 1, and a diagonal drawn from that point to the inner corner on the line 2. These dotted lines give the angle to which the wood must be cut to meet the other correctly when the parts are tilted. If the angles of sides and top were alike, this would apply to all the pieces, but the top, being more sloping, must be laid out similarly from the view C. If the joints are mitred as shown, and the edges represented in an inclined position, as in A, the true angles of the mitre are obtained by transferring the actual thickness, **3** to 4 C, to A, and the side, 5 to 6 B,

to the similarly numbered lines in A; 3 to 4 and 5 to 6 being tilted differently, it will be noticed, do not bear the same relation to the face lines in A. A diagonal from the inner to the outer corner of these edge lines gives the mitre. This, however, is always 45 deg. when the pieces to be mitred are of similar thickness.

Figure **156** is an example of a curved splay. A is a front elevation, B a vertical, and C a horizontal section. D is the inner curved surface of the splay supposed to be stretched out flat. A piece of paper or other thin, flexible material cut to this shape might be bent round, and would fit the inside of the splay. D is called a *face mould.* Such moulds are often employed for marking out the shape of work of complex curves. In this case it is not really necessary because the form is given definitely in the views A, B, and C, and material of the correct width would require only the semicircles marked on each face, and could then be worked in straight lines across from one to the other. The face mould is developed by continuing the lines of the splay in C till they meet at the centre O. From this centre the curves of D are struck, their starting-points corresponding with the edges of the face, and their length obtained by dividing the curve in A, and stepping off that in D to similar length.

Double Curvature. This is commonly known as *circle on circle* work. The form in which it is generally required is shown in **157**, A, B, and C. It represents the head of a door or window frame which is semicircular in elevation, as at A, and segmental in plan, as at B. C represents the side elevation. To form this two pieces may be jointed at the crown, or it may be divided into three or more parts according to its size. The elevation and plan being given as at A and B, it is developed in two parts as follows. The chord, 1, 2, is drawn in the plan, and the tangent, 3, 4, parallel with it. The distance between these lines gives the thickness of wood required. Face moulds D and E are made, and, when laid on the front and back faces respectively, serve as templets for marking the elevation curvature of A, on the flat surfaces, 1, 2, and 3, 4, and also the angles of the joints on the face. The moulds are obtained by dividing the outer semicircle in A into any number of parts, one of which is marked O, carrying vertical lines down from them to cut the line 3, 4, in B, and then carrying them back radially to the centre the curves of B are struck from, cutting the line 1, 2 in doing so. The line which starts from O in the elevation is also marked O at each of these two points in the plan. From these latter points lines are projected at right angles to the lines 1, 2, and 3, 4. The lengths of the vertical ordinates in A are now taken from the horizontal line up to each of the points where they intersect the outer and inner semicircles, and these heights are transferred to the corresponding ordinates which have been extended from the lines 1, 2 and 3, 4 in the plan B. The curves of the face moulds are then traced through the points thus obtained. The curvature in C is obtained by measurement with dividers from the straight lines 1, 2 and 3, 4, in B, to the curved ones contained within them, the measurements being made on the radial lines connecting the ordinates. If the jambs radiate as shown, this must be allowed for in placing the moulds.

Mouldings. The main elemental forms of moulding are shown in **158** to **173**. More complex forms are made up chiefly of a combination of these. The Grecian and Roman differ in form in some cases, though the same names are applied to both. The Grecian are generally considered more graceful, especially in curves like the ogee, which in the Roman change abruptly in direction. The Grecian curves are mostly elliptic or parabolic in form. The Roman are all parts of circles. The listel [**158**] is always used in combination with curves. The astragal [**160**] is a small semicircular projection running horizontally. When vertical, it is a cocked bead. When flush with the surface, with a quirk or groove at its side, it is an ordinary bead. The Roman torus [**163**] differs from it only in being much larger and having a fillet on one side. The Grecian [**162**] is a parabolic sweep projecting about two-fifths of its depth. The Roman ovolo and cavetto [**165** and **167**] are quarter-circles; the Grecian [**164** and **166**], are parabolic and elliptic curves. The cyma recta is two-quarter ellipses in the Grecian [**168**] and quarter-circles in the Roman [**169**]. The cyma reversa is, in the Roman [**171**], merely reversed in position; in the Grecian [**170**] its form is also modified. The scotia [**172** and **173**] is a compound curve in both Grecian and Roman, but proportioned differently. Except those which are parts of circles, none of the sweeps are rigidly fixed in contour, but are required merely to have a graceful appearance. Their normal proportions are indicated by divisions on the straight dotted lines. For working these mouldings by hand, planes of the correct form in various sizes are generally employed.

Enlargement and Diminution of Mouldings. The most convenient method of obtaining proportionate enlargements or reductions of mouldings is by means of radiating lines, as in **174**. The example shown is a plain cube, but if its form were irregular it could be treated in the same way by adding any number of intermediate radial lines.

A simple method of enlarging a moulding is shown in **175**, where A is enlarged at B by projecting parallel lines from it to cut a diagonal of the required length. The thickness of A may be increased similarly.

In **176** the moulding A is reduced to B by drawing horizontal and vertical lines from its chief points to meet the lines XX at right angles to them. From the points XX in each case equilateral triangles are drawn to the points O, and the intermediate lines from the moulding are converged to those points also. The lines 1 1 across these triangles represent the diminished size of the moulding, and the converged lines may be projected along to it in one direction and transferred with dividers in the other. If the moulding is to be proportionately reduced in both directions the horizontal and vertical lines 1 1 must bear a definite relation to each other. Supposing the longer or vertical one to be decided on first, the length of the other is obtained by taking the horizontal length XX and transferring it from X to 2 on the vertical line XX. From 2 a radial line is drawn to O, which gives the length 3 1 on the vertical line 1 1; 3 1 will be the required length of the horizontal line 1 1.

Raking Mouldings. When the ends of horizontal or vertical mouldings meet the ends of inclined ones, as in skirtings, pediments of doors and windows, and various constructions, the sloping joint of the inclined one must correspond in depth with the square end of the other, and the depth of each measured square across cannot therefore be the same. The entire contour of the moulding also must be correspondingly modified in cross section to make the two pieces match at the joint. In **177** we may suppose moulding fitted round a square body with a bevelled top. At A and C

horizontal moulding is seen in end view, and at B a section is given of inclined moulding for connecting A with C. Supposing the section at A already decided on, the required sections of the other two are obtained as follows. With the exception of the fillet at the top the moulding has no definite points from which lines can be projected, and therefore it is necessary to divide the curve into parts. From the points 1, 2, 3, 4, 5, 6, lines are carried up to the horizontal line above, and transferred from there to the correspondingly numbered points on the slope, and from there continued across at right angles. Lines running parallel with the slope are also carried from the divisions on the curve in A, and where they intersect the other lines, points are given through which the contour of the inclined moulding is traced. The divisions on the top surface are again repeated at C, and the verticals carried down to intersect the lines parallel with the slope, giving another set of intersections through which the contour of C is traced. The curved line XX in the lower part of the figure indicates how a curved or *sprung* moulding would be treated, all the lines following the slope then being curved to correspond with it.

Figure **178** is an example of vertical angle bars of a shop window. Their ends are fitted to horizontal rails, and their points and backs are required to be in line, no matter what angle they lie at. The shape of the curved portion may be obtained by divisions as shown. Fig. **179** shows raking bars such as might be used in a lantern light or greenhouse roof. A is at the ridge, B and C are sections through two different slopes, and D is a horizontal piece at the eaves. In these there are no curves, and it is necessary only to draw lines from their angles.

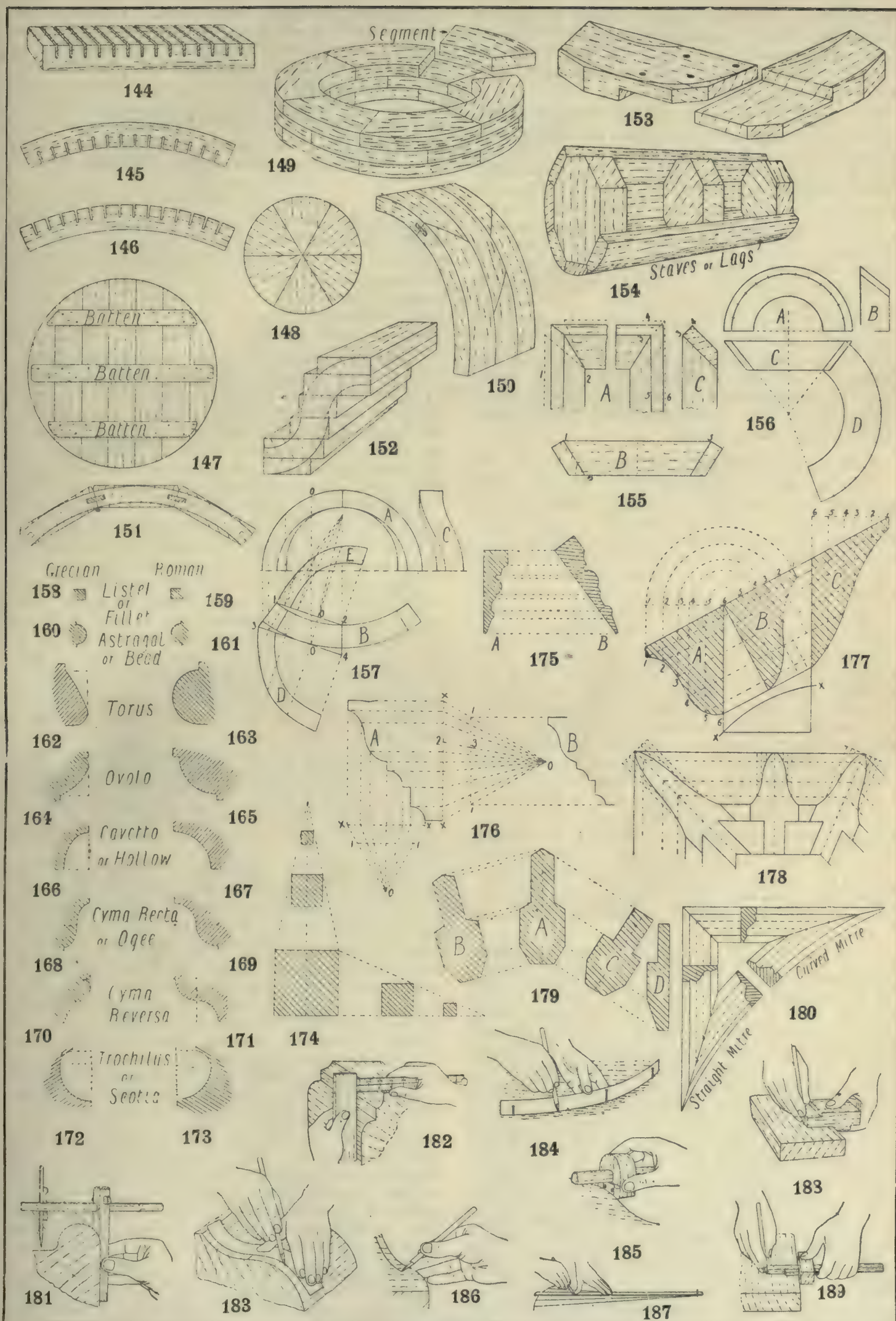
Mitres of Curved Mouldings. With these straight mitres can only be employed under certain conditions. Fig. **180** is an instance where a straight mitre necessitates making the section of the curved moulding different to that of the straight one which it joins. By curving the mitre, two mouldings of similar section may be made to match at the joint. The curve is obtained by running a number of lines parallel with each and tracing the curve through their intersections. The modified moulding is obtained by making its lines meet those of the other on a straight mitre. Curved mouldings of similar radius and section will join with a straight mitre when their concave or convex sides are towards each other, but not internal curve with external

Methods of Marking Out. The long-tooth, or grasshopper gauge is used as in **181**, for gauging lines on different levels, or when an intervening projection prevents an ordinary gauge from being used. An alternative is to mark the distance at each end and rule a line through, but in some cases this is not possible. Measurements are made, as in **182**, when the rule cannot be applied directly from one point to another. A flexible strip of steel or wood is often used for marking curved lines, either on a curved surface as in **183**, or by bending it to a suitable sweep, passing through the points required, as in **184**. The alternative to **183** is to fit a piece of wood or cardboard to the contour and mark against one of its faces, or to gauge from an end face. Curved lines may be gauged parallel with a curved edge by using an attachment to the gauge, as in **185**. Fig. **186** shows a rough method of marking such a line by hand. Much trouble may be saved, in marking a number of radial lines some distance away from a centre, by driving a pin into the centre for the straightedge to bear against, as in **187**. Figures **188** and **189** show methods of gauging pencil lines when a considerable number are required alike. Fig. **188** is a block of wood rebated to the required distance and slid along the work with the pencil held against it or in a notch. Fig. **189** shows a gauge used similarly. Figs. **190** and **191** show an easy way of reducing the thickness of a piece of wood when it cannot be sawn. It can be cut with less effort when the tools are used diagonally across the grain than when in the same direction. The edges are first bevelled down to the gauge lines. Then, if the amount to be removed is very much, a gouge is used first, and then a jack plane until the surface is almost down to the gauge lines. After that the planing is done in line with the grain. Spokeshaves are used as in **192**, and drawknives as in **193**, with the work held in any convenient manner, usually in the vice. The spokeshave is used either from or toward the workman, as most convenient; the drawknife always toward.

Staircases. This, with handrailing, is a branch of joinery requiring special knowledge and skill. The arrangement of stairs should be decided on in planning a building, and the carpenter should consider them in laying the floor joists, as these latter sometimes have to extend through a wall to form a landing in the stairs. As in most other work, staircases are put together as far as possible in the workshop. Stairs should be arranged to make communication between floors as easy as possible. Two straight flights in opposite directions with a landing midway, are less tiresome to use than one continuous flight. A landing is also better than winding stairs at a turn. The latter are adopted only when the total rise and confined space demand it. The height and width of each step should bear a certain proportion to each other. An increase in one direction should mean a diminution in the other. Thus a step may be wide and shallow or narrow and high. If this rule is departed from, they are tiresome to use. A rise of 7 in. with a tread of 9 in. or 10 in. wide, is found the most convenient, but unless the total rise and total amount of *going* in the forward direction are adapted for this it has to be modified. The joiner marks the exact rise and going of his staircase on a storey rod, and from this the number and size of the steps are decided. A storey rod is simply a long rod about 1½ in. square, on which the total lengths are marked.

The individual steps of a staircase have to be secured at their ends to timbers called *strings*, which follow the slope of the staircase, and when the width of the stairs is considerable, or when laths for plaster have to be nailed across the under surface, one or more intermediate *carriages* are added. Landings and the ends of strings and carriages are supported by joists from the walls, and often also by newel posts extending to the floor below. The boards of landings are usually buttoned instead of nailed to the joists. Where flights of stairs occur above one another a height of not less than 6 ft. must be allowed between the nearest points for headroom. Staircases usually have a wall on one side while the other is open and provided with the handrail and balusters.

Principal Types of Stairs. There are four principal types of stairs, three of which are shown in plan in **194** to **196**. The simplest kind are straight, consisting of one flight, sometimes with winders at the bottom. *Winders*, which is the term applied to winding or radiating steps, are never used at the top of a flight if it can be avoided.



JOINERY

144.-146. Saw-cuts in wood to facilitate bending 147-154. Methods of building up 155 and 156. Examples of splayed work 157. Example of circle on circle 158-173. Mouldings 174-176. Enlarging and diminishing mouldings 177 and 179. Raking mouldings 180. Mitres of curved mouldings 181-189. Methods of marking out

The next form is shown in **194**. These are known as *dog-leg*. They consist of two or more straight flights running in reverse directions, either with or without winders at the turns, and with their handrails in the same vertical plane.

The foregoing are the two commonest types. The others occupy more space and are used chiefly in high-class houses and public buildings. One is known as the *open well*, or *open newel*, type [**195**], and the other as *geometrical* stairs [**196**]. The open newel, in common with the straight and dog-leg types, have newel posts at each change of direction in the stairs and handrail. They differ from the dog-leg in having lateral space, called a *well*, between the flights. In making a turn the flights then are generally at right angles with each other instead of turning a semicircle from one flight to the next. Geometrical stairs may be of several varieties, but they differ from all the foregoing types in having no newel posts, the handrailing and stairs being made to change direction without sharp turns. These must not be confounded with spiral stairs, which have a central newel.

Details of Strings and Steps. Figure **197** is a back view of a portion of a straight flight supposed to be on the bench in course of construction. The strings usually differ in character as shown. The one which goes against the wall is a parallel board 1½ in. or 2 in. thick with recesses ⅜ in. or ½ in. deep cut in its face to receive the ends of the steps. These are tightened by wedges as shown and afterwards nailed from the other side, besides having glue-blocks in the interior angle. Sometimes the string is thickened up by nailing brackets within to supplement the depth of the housing. The other string has its upper edge serrated to the shape of the stairs, and the ends of the *treads*, or horizontal boards of the steps, rest on it. In cheap work they project an inch over to form a nosing similar to that on the front edges of the treads. The baluster ends are then housed about ¼ in. into it. But the usual method is to dovetail them in at the side and fit the nosing on after, by tonguing, secret screwing, or roughly by nailing. The front and side nosings are mitred at their joint. The *risers*, or vertical boards of the steps, are usually stop mitred to the strings as shown. Another method is to mitre them to ornamental brackets as in **198**.

Steps are first glued up separately as in **199**. Figures **200** to **203** show various methods of jointing the treads and risers. Fig. **203** is known as *slot screwing* and is a plan adopted in many other instances. It allows the tread to shrink or swell in width without breaking the joint or splitting the wood. The recesses for treads and risers in the wall string are marked out by templets of similar length and thickness to those parts plus the amount for wedging. The steps are afterwards fitted separately and numbered ready for the final gluing up. The positions of the steps on the string are marked by a templet called a *pitch board*, which is a thin triangular piece of wood with two of its edges at a right angle representing the length and depth of one step. This is slid along the string against a guide behind it, which keeps its point to the nosing line of the stairs, and its angle in correct position. This is used on both housed and *cut* strings. The latter name is given to strings which are notched out, as in **197** and **198**. Occasionally, housed strings are fitted to the outer side of a staircase, but usually they are on the wall side and the outer ones are cut.

Landings and Winders. Landings are either half or quarter space, according to whether they extend across the width of two flights, as in **194**, or only one flight, as in **195**. The usual method of arranging their joists are shown in those figures. Winders at quarter turns are divided into three, as **195**, and templets made to mark the shapes of the treads by. The ends of the treads and risers that radiate from the newel post are housed into it.

It is bad practice to have the nosing of a winder radiating into the angle of the walls. It should be divided as in **195** and **196**. It is best, also, instead of radiating from the centre of the newel, to make the treads as wide as possible round the newel. Winders generally have to be built up in place, but as much as possible of the work is done in the shop, where there are better facilities for doing everything.

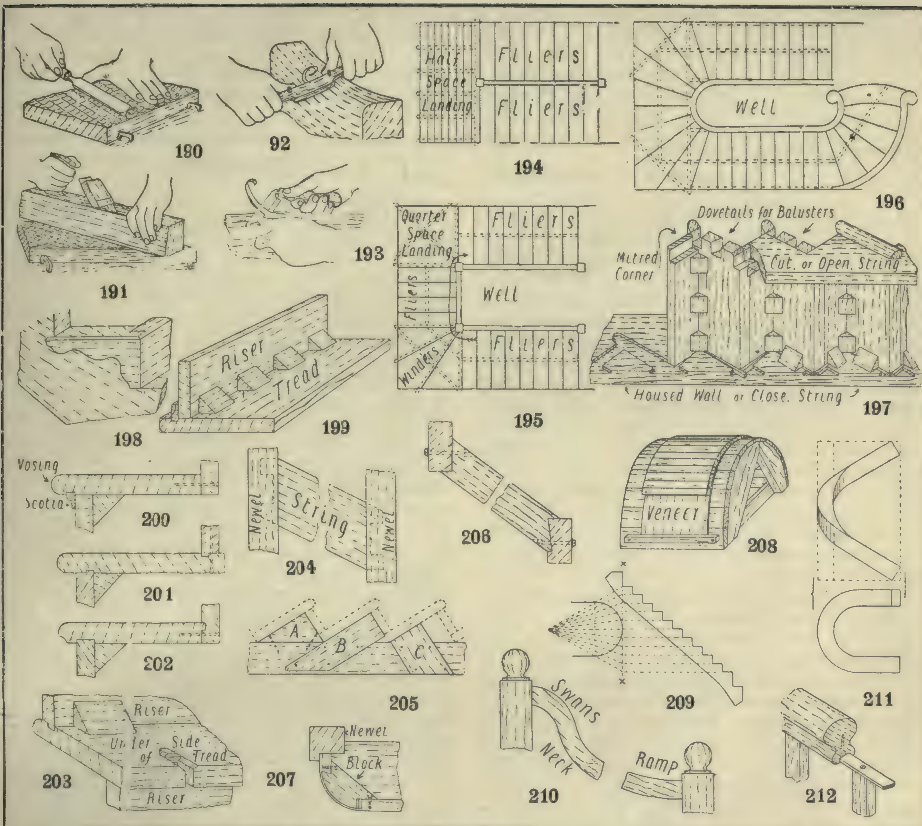
Newel Posts. These are 4 in. or 5 in. square, with portions turned. In some cases they extend to the ground floor and help support the staircase, while in others their chief purpose is to support the handrail, and they terminate a few inches below the string in an ornamental end. Where they are employed the strings are tenoned into them as in **204**, and pinned. Newels are secured to joists by bolting them against the side, generally with a cogged joint. This is done at landings where a joist or trimmer crosses the newel, and at the base when newels extend to the ground floor.

Carriages. The under edges of these should be flush with those of the strings. To avoid great depth they are generally stiffened and made to afford support to the treads by nailing rough pieces on either their sides or upper edges as in **205**, A, B, C. Their ends are fitted to joists or trimmers as in **206**. Under winders they are framed into *pitching pieces*, which are fitted between newel and wall.

Bullnose steps are formed by bending thin wood round a rough interior block, as in **207**. The riser is sawn down thin where it is to be bent, and is glued and tightened by wedges at one side. Screws are afterwards put through into the thick part as shown.

Geometrical Stairs. These have no newels to receive the ends of handrails at the turns, but the rail is supported entirely by balusters, and changes its direction in curves. The outer string also must curve similarly round the well. This may be done either by staving it up or by reducing its inner face to a veneer, and bending it round a cylinder of the required size and gluing staves on the back [**208**]. Another way is to bend and glue several thicknesses of thin wood together round the cylinder, keeping them there till the glue is set. Fig. **209** shows the method of obtaining the stretched out shape of a semicircular bend like that in **196**. The divisions on the line XX represent the semicircle stretched out flat. This may be done in a number of ways. The one shown is by projecting lines from an equilateral triangle through the points on the curve. From the line XX they are carried in parallel lines giving the tread widths. The drawing is developed by adding the riser heights, which are all alike.

Handrailing. In stairs with newel posts the handrail is usually straight and tenoned into the posts at each end. Its inclination follows that of the staircase. Its height should generally be 3 in. or 4 in. more on a landing than on the stair incline. Its inclination over the narrow ends of winders is naturally much greater than over full-



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190-193. Some methods of working **194.** Plan of dog-leg staircase **195.** Plan of open well staircase **196.** Plan of geometrical staircase **197.** Fliers in course of construction **198.** Bracketed string **199-203.** Details of steps **204.** String tenoned into newels **205.** Brackets on carriages **206.** Carriage ends fitted to trimmers **207.** Bull-nose step **208.** Staving veneer on a cylinder **209.** Development of wreathed string **210.** Bends in handrail **211.** Wreath **212.** Iron core in rail

width fliers, and therefore its height above the treads of winders should be correspondingly diminished to make it convenient for use. For this reason straight rails are sometimes curved in elevation at each end, as shown in **210**. In geometrical stairs the handrail is supported only by the balusters beneath it, and is winding or twisted in form to follow correctly the turns round the well while rising simultaneously with the stairs. These are termed *wreaths*, and the work connected with them, and often the proportioning of the steps below them to obtain a graceful sweep, is done by specialists. The principle on which a wreath is formed is shown in **211**, which gives elevation and plan of a semicircular wreath. The actual marking out involves a great deal of geometry, and to go into details would occupy more space than can be afforded in this course. The joints in rails are usually square, and are held generally together by a handrail bolt and by two dowels.

Balusters. Balusters may be housed or tenoned into the under surface of the rail, or skew-nailed either into a groove or merely against the surface. A very substantial method often adopted for geometrical stairs, is shown in **212**. An iron core is screwed to the tops of the balusters, and this is screwed into a groove in the under surface of the rail. Balusters may be either plain square rods, or rendered more ornamental by having their middle portions turned. The turned portions should be of similar length, and follow the angle of the string and rail, the square ends being varied in length according to their positions on the treads. In most cases two balusters occur on each tread, one over the nosing, and the other equally divided horizontally between that and the next nosing. The dovetails are marked by templet on the ends of the treads. In geometrical stairs iron balusters of similar pattern to the wood ones are placed at intervals to afford substantial support to the handrail.

JOINERY *concluded; followed by* PLASTERING

Group 13
COMMERCIAL GEOGRAPHY
7
Continued from page 5121

THE WORLD'S MINERALS

Coalfields and their Resources. Petroleum and its Uses. Iron and Steel. Gold and Silver. Other Metals. Precious Stones

By Dr. A. J. HERBERTSON and F. D. HERBERTSON

COAL is derived from the vegetation of past geological epochs, subjected for vast periods of time to great pressure and heat. The result of a long series of slow chemical changes is to get rid of a large proportion of the hydrogen and oxygen, and to increase the proportion of carbon [see NATURAL HISTORY]. *Peat*, abundant in the bogs of Ireland and other parts of the world, shows an early stage of the process. The fibrous arrangement is still clearly seen. There is a large proportion of water, and owing to the smaller proportion of carbon the heating power of compressed peat is only about one quarter of that of coal. *Lignite*, with 70 per cent. or less of carbon, is intermediate between peat and coal, but the harder varieties, known as brown coal, closely resemble the latter. Some of the vast lignite deposits of North America are an excellent substitute for coal.

The Two Kinds of Coal. Of coal there are two well marked kinds—soft or bituminous coal, with 50 per cent. or more of carbon, and anthracite, with as much as 94 per cent. *Bituminous coal* lights readily, burns with a flame, and produces a varying amount of smoke. Its varieties are very numerous, one of the best marked being the well-known cannel coal. *Steam coal*, intermediate between bituminous coal and anthracite, contains little bitumen, so that it is smokeless, while the high proportion of carbon gives great heating power. This steam coal is in great demand for naval use. *Anthracite* is hard to light, burns without flame, and gives out great heat. Its smokelessness makes it very suitable for use in cities, as in the United States. It is also used in brewing.

Coke is produced by heating bituminous coal away from the air. The volatile substances are driven off, and the residuum approximates in properties to anthracite. Coke is an important by-product in the manufacture of coal gas. It burns with intense heat, and its freedom from sulphur makes it valuable in many metallurgical operations. Coals are often spoken of as coking, or non-coking. The former, which cake or fuse in burning, are preferred for special purposes—for example, as fuel for locomotives.

Growth of the Use of Coal. The use of coal is of no great antiquity in Europe. Whatever may have been the case locally, it was not used in London before the thirteenth century. In the seventeenth century the total production in England had reached over 2,000,000 tons. The introduction of steam power enormously increased the consumption of coal, and resulted in a redistribution of population in England and other countries.

Coalfields of the World. Estimates of the total area of the World's coalfields differ widely. The area can hardly be far under 500,000 sq. miles. According to Mr. Chisholm, there are approximately 250,000 sq. miles in North America, chiefly in the United States. The coalfields of China cannot be less than 200,000 sq. miles, and may be more. The coalfields of Britain may be put at about 12,000 sq. miles, while those of the Empire are roughly 140,000 sq. miles. Russia has about 20,000 sq. miles; Spain, 5,000; France, Germany and Austria-Hungary, round about 2,000; and Belgium, 500 sq. miles. Area, however, affords no satisfactory basis for estimating the actual resources. Much coal lies at a depth impossible to work, as, for example, on the South Wales coalfield, where the coal-bearing strata are 10,000 ft. thick. In other cases the seams may be so thin as not to pay for working, or the quality may be inferior. Temperature increases rapidly though not uniformly with the depth of a mine, rendering extraction beyond a certain depth a physical impossibility [see MINING]. The element of cost has also to be taken into account in deep mining. At the present time a depth of 4,000 ft., and a seam thickness of 2 ft. are commonly assumed as working conditions. No mine yet reaches this depth, though the deepest mines of this country and of Belgium are not far short of it.

How Long Will Our Coal Supply Last? The ever increasing demand for coal has led to investigations into the probable duration of our coal supply. Two Royal Commissions have reported on the subject, the second in 1904. On the workings of 1903 our reserves would apparently last for 600 years, but the output is not likely to remain steady. More probably it will reach a maximum within no distant period, and then almost imperceptibly decline owing to the gradual increase of working cost.

The largest coalfields of Britain are those of (1) Central Scotland, in the rift valley between the Scottish Highlands and the Southern Uplands; (2) South Wales; and (3) the marginal coalfields of the Pennines in the north-east, south-east, and south-west.

The Coalfields of Scotland. The Scottish coalfield is divided into the Ayrshire coalfield, the Central, or Forth and Clyde coalfield; the Fife coalfield; and the Midlothian coalfield. The estimate furnished to the Royal Commission of 1904, was that more than 15,000,000,000,000 tons are available, including workable coal under the Firth of Forth. The bulk of this is in the counties of Fife (with Kinross), Lanark, the

Lothians, Stirling and Ayrshre. The output for 1904 was 35,500,000 tons, half of which was from Lanarkshire, which feeds the great industrial region of which the Clyde is the centre and outlet.

The South Wales Coalfield. The South Wales coalfield ranks next in size, with an area of over 900 sq. miles. Deeply cut valleys penetrate into this mountainous region, bringing the outcrop to the surface and enabling the seams to be worked cheaply. This explains why the mines were long and shallow as compared with those of the North of England, though many are now carried to over 10,000 ft. The ports at the mouths of the valleys, of which the most important are Llanelly, Swansea, Cardiff, Barry, and Newport, are well placed for exporting coal cheaply. Much is used locally for iron smelting, the tin plate manufacture, etc. The eastern part of this field consists of bituminous coal. The centre supplies most of the steam coal for the Navy, while anthracite is mined in the western part. More than 26,000,000,000 tons are estimated to be available within 4,000 ft., half being steam coal. At the rate of output in 1903 (42,000,000 tons) this would last about 600 years.

The Coalfields of the North of England. The coalfield of Yorkshire, Derby, and Nottingham, the largest in England, is about 750 sq. miles in area. The Silkstone is one of the best seams. It is continuous with the Arley coal of the Lancashire coalfield, and must originally have covered an area of 10,000 sq. miles. The Barnsley coal is of a semi-anthracite character, developing a great heat either as engine or smelting fuel. The estimated amount of workable coal in 1903 was over 26,000,000,000 tons, available for 500 years at the rate of 1903 (52,000,000 tons). This coalfield supplies the Yorkshire woollen and iron industries.

The Durham and Northumberland coalfield also lies east of the Pennines. The seams which run under the sea might probably be followed for about three miles. A famous seam is the Wallsend, five or six feet thick. Newcastle coal is in great demand in London, and also locally for the vast iron industries of the Tyne and Tees. The output in 1903 was nearly 45,000,000 tons. The area of visible coalfields was estimated at 460 sq. miles, in addition to 225 sq. miles of concealed coalfields and 111 sq. miles under the sea. The estimated amount of workable coal was estimated in 1903 at nearly 9,000,000,000 tons.

Two important coalfields, those of Cumberland and Lancashire, lie on the western flank of the Pennines. In the Cumberland coalfield all the coal lies within 2,000 ft. of the surface. It is chiefly mined round Whitehaven, Workington and Maryport, and the workings have been carried about three miles under the Irish Sea. The amount of coal available has been estimated at 1,500,000,000 tons, which at the rate of 1903 (over 2,000,000 tons) would last about 700 years.

The South Lancashire coalfield, which extends into Cheshire, is an irregular area of over 200 sq. miles. Its output in 1903 was not far short of 25,000,000 tons, a great part of which feeds the great cotton and iron industries of Lancashire. The southern part of this coalfield is one of the most densely populated parts of Europe. The estimated reserve is 4,340,000,000 tons.

Coal for the Black Country. The North Staffordshire coalfield is not very large (75 sq. miles), but it has thick seams of workable coal. The coal-bearing strata are perhaps 5,000 ft. thick, with a total thickness of workable seams amounting to nearly 3,000 ft. Workings are carried down to nearly 3,000 ft. This region is not yet developed to anything like the extent possible, since few districts in the United Kingdom are so richly endowed with mineral wealth. The South Staffordshire coalfield, on the contrary, once enormously rich, has been much depleted to feed the furnaces of the Black Country. The whole country between Wolverhampton, Dudley and Birmingham forms one great workshop [see 72, page 1274]. Professor Hull has vividly described the scene at night, as viewed from the walls of Dudley Castle, in the centre of the coalfield. "The whole country within a radius of five or six miles is seen to be overspread by collieries, iron foundries, blast furnaces, factories, and the dwellings of a dense population, and from amidst the thick smoky atmosphere the tongues of fire from the furnaces shoot up an intermittent light which illumines the whole heavens. But the spectacle does not represent the whole sum of human labour, for whilst 10,000 hands are at work above ground, one half as many, perhaps, are beneath the surface hewing the coal which is to be the prime mover of the whole machinery in motion above ground." The total thickness of the workable seams in the Dudley district is about 65 ft., a famous seam being the Ten-yard, with a general thickness of 30 ft. Probably nine-tenths of this rich seam are now worked out, drowned, or otherwise destroyed. In this area of 93 sq. miles, there were perhaps 1,400,000,000 tons still available in 1903, in which year over 13,000,000 tons were raised in the two Staffordshire coalfields.

The Warwickshire coalfield has the advantage of being the nearest to London. The area at present worked is about 30 sq. miles, with perhaps 30 ft. of workable seams. It may yield nearly 850,000,000 tons. The output in 1903 was rather under 3,500,000 tons.

Some Minor Coalfields. The Bristol coalfield, which extends to Gloucester and over much of Somerset, has two series of coal-bearing strata, separated by harsh sandstones. The total area has been put down at 150 sq. miles, of which all but 45 sq. miles are concealed by more recent formations. The output in 1903 was about 1,500,000 tons, and it was estimated that over 4,000,000,000 tons might be available. Of this more than one-eighth is steam coal, suitable for the Navy.

There are numerous smaller coalfields, such as those of North Wales, Coalbrookdale, and the Forest of Dean. The total output for the whole of England in 1904 was over 161,000,000 tons, while Wales produced about 35,500,000 more.

The total for England and Wales was thus nearly 197,000,000 tons, giving a total for Great Britain of over 232,000,000 tons.

The Irish coalfields are small and little developed. The most important are those of Dungannon in Ulster, and of Kilkenny in Leinster. The output in 1903 was only 100,000 tons. About 175,000,000 tons are estimated to exist.

Total Coal Resources of Britain. The recent Royal Commission estimated that there existed reserves of coal amounting to nearly 101,750,000,000 tons in visible coalfields, and to over 39,000,000,000 tons in concealed coalfields. This vast amount, enough at the rate of 230,000,000 tons a year to last for six centuries, includes none more than 4,000 ft. below the surface, or more than three miles under the sea. The value of the estimated output is about £95,000,000 annually.

The quantity of British coal exported has for several years exceeded 40,000,000 tons. In 1904 it exceeded 46,000,000. This does not include bunkerage for consumption on board ship, which amounted in 1904 to over 17,000,000 tons, making a total of nearly 64,000,000 tons, or over 30 per cent. of the output. France, Germany, and Italy are the largest importers.

For a list and map of the British coalfields, see pages 987 and 988, and for the use to which the coal of each field is put, see the "Industry and Trade of Great Britain," in a later article.

Russian Coalfields. The coalfields of Russia are nearly twice as great in area as those of Britain; those of Spain are less than half as great as our own. Here, again, area is not the proper basis of calculation, for Germany, with less than one-tenth of the actual area of the Russian coalfields, is the third largest producer in the world.

The coalfields of Russia are found (1) in South-west Poland; (2) in the Donets basin, covering an area of over 10,000 sq. miles; (3) in Central Russia round Moscow; and (4) in the Urals. Beyond the confines of European Russia are the coalfields of the Caucasus and the Altai. The Moscow, Donets, and Polish coalfields are all developing rapidly. The present output of Russia is about 16,000,000 tons, valued at nearly £7,000,000.

Spanish, French, and Belgian Coalfields. Between Santander and Oviedo is the potentially rich coalfield of Asturias, with 60 workable seams of good quality. There are also rich deposits in Eastern Spain. The present output, however, is small, being under 3,000,000 tons, valued at less than £1,000,000.

The important Franco-Belgian coalfield stretches from near Aachen to Calais (210 miles), where the strata dip beneath the Channel, to reappear near Dover and in the Bristol coalfield. On this coalfield are the iron towns of Liège, Namur, and Mons in Belgium, the cotton town of Lille in France, and many smaller industrial towns in both countries. The total area is about 1,200 sq. miles, but the strata are in places interrupted by or buried beneath the chalk.

In Central France, on the flanks of the Central Plateau, are many small fields of which St. Etienne is the busiest centre. This also supplies the silk industry of Lyons.

The present output of France exceeds 32,000,000 tons, valued at £19,000,000. The Belgian output is 22,000,000 tons, valued at £13,000,000.

The Coalfields of Germany and Austria-Hungary. The Saar coalfield is the largest in Germany (900 sq. miles), supplying the rapidly growing industries of Alsace-Lorraine. The strata probably descend to 20,000 ft., so that the full resources can never be utilised.

The Westphalian or Ruhr valley coalfield extends from the Rhine at Duisburg and Ruhrort for about 40 miles up the Ruhr valley. The great iron towns of Essen and Barmen-Elberfeld are on the coalfield, which also exports coal by the Rhine.

The other important coalfields are in Saxony, on the flank of the Erz Gebirge, or Ore Mountains, and in Silesia, on the flanks of the Riesen Gebirge, and in the extreme south-east at the western end by the Polish field. The total output of Germany is about 130,000,000 tons, about half that of Britain, valued at £55,000,000.

In Austria-Hungary coal is found in Bohemia, Moravia, and Silesia, in the flanks of the Central European Highlands. There is practically no coal in the Alpine provinces, but some lignite is found in Styria. The output is about 40,000,000 tons, valued at £9,000,000.

In the other countries of Europe coal is unimportant.

The Coalfields of Asia. China probably possesses the largest and richest coalfields in the world. The province of Shansi, in Northern China, has seams of coal 40 ft. thick, and easily accessible. Iron is also abundant, and the whole region is destined to become a second and richer Pennsylvania The deposits are continued in the adjoining province of Honan. In the Yangtse basin of Central China, and especially in the Red Basin of Szechwan, coal is exposed in the gorges of the Yangtse and its affluents, needing only to be followed by adits, as in South Wales. There are also coalfields in Hunan and Kwangtung in Southern China, in Manchuria, and in Korea. Japan has coalfields in Kiushiu, Yezo and Formosa. In Tongking there are coal seams 70 ft. thick. Still further south coal is found in Borneo.

Coal is found in many parts of India, but most abundantly in Northern India. The most important coalfield at present worked is that of Raniganj (500 sq. miles), about 120 miles from Calcutta. The output of India is at present only 7,000,000 tons.

Australasian and African Coalfields. Important coalfields lie between the Great Dividing Range and the Pacific Ocean, in New South Wales and Queensland. Newcastle, at the mouth of the Hunter River, is the outlet for the mines of that district. At Brisbane, the capital of Queensland, says Professor Hull, quoting the famous Australian geologist Clarke, "steamers can load by lying literally at the mouth of the mines," for the coal seams are exposed close to the sea and are accessible by adits. Tasmania is

also well provided with coal. In New Zealand North Island has considerable deposits of lignite, while South Island has both lignite and coal.

Africa is poorly provided with coal in comparison with the other continents. A little is found in Abyssinia and British East Africa, but the rich coalfields of the continent are south of the Zambezi, in British territory. Large deposits of good coal occur in Rhodesia, the Transvaal, and the Orange River Colony. Good bunker coal is obtained from Newcastle and Dundee in Natal, and there are also deposits in Eastern Cape Colony. If, as some geologists think, these are parts of a single great coalfield, the potential resources of South Africa are considerable.

Coalfields in the New World. Coal is very unequally distributed in the New World. In South America it occurs in parts of Venezuela, Southern Brazil, Uruguay, Argentina, including Southern Patagonia and Tierra del Fuego, Chile, and Peru, but not to any great extent. The output of Chile, though increasing, is not yet large. The coalfields of North America vie with those of Eastern Asia in extent and value.

Rich coalfields are worked in Nova Scotia in the east, and in Vancouver Island in the west of Canada, the Nanaimo mines of the latter yielding the only good coal of the Western Pacific shores. In the interior, coal occurs from Manitoba westwards, especially in the Rocky Mountains, but owing to the lack of communications and population, only a fraction is worked. The coalfield west of the Crow's Nest Pass, now reached by the railway, is said to be one of the most extensive deposits in the world. Unfortunately, Eastern Canada, the most densely-populated part, is destitute of coal, and imports much from the United States, Buffalo being the chief lake port.

Coal in the United States. The United States ranks first among the coal-producing countries of the world, with an output of 284,000,000 tons, valued at nearly £85,000,000. Coal is said to underlie about one-sixth of the country, but estimates of the total area of the coalfields vary considerably. Those of the late Professor Rogers made it about 197,000 sq miles, but the later estimates of Professor Hitchcock raise it to nearly 230,000 sq. miles. Other estimates put it at a still higher figure. The figures given below are those of Professor Hitchcock. Bituminous coal is mined in twenty-five States, Pennsylvania, Illinois, Western Virginia, and Ohio coming first. Much coal is locally used, especially in the busy region round the Upper Ohio.

The coalfields of the United States are (1) the Appalachian field, extending from New York to Alabama, a distance of 900 miles, through the States of Pennsylvania, Maryland, West Virginia, Ohio, East Kentucky, Tennessee, Georgia, and Alabama. In West Virginia the thickness of coal is about 50 ft. The total area of the coalfield is over 63,000 sq. miles. The coal is often exposed in the deeply-cut mountain valleys, so that it can be easily and cheaply worked. The numerous rivers transport it cheaply to the towns and industrial centres. Its combination with iron in Western Pennsylvania has created the great iron industries which centre round Pittsburg. In this region, and especially at Connellsville, is made three-quarters of the coke of the United States, used chiefly in the pig iron industry. The output of Pennsylvania is about 82,000,000 tons of bituminous coal. New York ranks next to London as a coal market.

The Central Coal Basin, east of the Mississippi, in the States of Illinois, Indiana, and Western Kentucky, is over 51,000 sq. miles in extent, with a maximum of 30 ft. of coal. The northern or Michigan basin is small, under 7,000 sq. miles, with a maximum of 11 ft. of coal. West of the Mississippi is the vast West Central or Missouri coalfield, with an area of over 100,000 sq. miles, in the States extending from Iowa to Texas, and including parts of Nebraska, Missouri, Arkansas, and Indian Territory. Much of the Texas coal, however, is poor in quality. There is also coal in parts of the Rocky Mountains, and in parts of the Pacific coast.

A Vast Deposit of Anthracite. Pennsylvania also leads in the production of anthracite, turning out about 55,000,000 tons a year. The deposit area of anthracite, Susquehanna, Lehigh, and the Schuylkill valleys of Eastern Pennsylvania, is estimated at about 450 sq. miles. A species of anthracite, resembling graphite and very difficult of combustion, is found in the New England basin, estimated at 750 sq. miles in area. Small deposits are also found in Colorado and New Mexico. Lignite is abundant in the western part of the Central Plain, and round the Gulf of Mexico.

Most of the United States coal is absorbed by the home market, though increasing quantities are exported to Canada, the West Indies, Central and South America.

In Mexico coal is found in several parts, but at a height of from 2,000 to 4,000 ft. above the sea. There is also some coal in Central America and the West Indies.

The world's output of coal at the present time thus amounts to over 800,000,000 tons a year, valued at nearly £300,000,000.

Petroleum. Petroleum is a liquid mineral product, stored in subterranean reservoirs. These are generally reached by boring, but there are also "gushers," or free-flowing wells, yielding many thousands of gallons daily, much of which runs to waste before storage apparatus can be erected. The crude oil is usually carried in pipes to the centres from which it is distributed, refined, or unrefined, as the case may be, by pumping it into tank cars or tank steamers.

Petroleum is widely distributed. It is found in Germany, Galicia, Rumania, and on a vast scale in Southern Russia in Transcaucasia. The petroleum of the oil-fields of Burma is carried by pipes to Rangoon, for the Indian market. The line of deposits is continued in the islands of the Eastern Archipelago (Java, Sumatra, Borneo, the Philippines), near Sydney, in New South Wales, and in New Zealand. Africa has workable deposits in Algeria and Cape Colony. The oil-

fields of North America vie with those of Russia. Those of South America (Peru, Venezuela, Argentina) are less considerable.

Baku, on the Caspian Sea, is the chief centre of the Russian oil industry, which in 1901 produced nearly 300,000,000 gallons. Political strife and insurrections have greatly injured it in the last year or two. Much of the output goes across the Caspian to Astrakhan and the Volga for the European markets. Some is distributed through Batum and Poti, on the Black Sea. The restriction on sending oil in bulk through the Suez Canal is now removed, and Port Said is the depôt for the Eastern market.

Petroleum in the New World. The first boring for petroleum in the United States was made in Pennsylvania in 1859. The product was refined round Pittsburg and Oil City. This region still leads in output, with 20,000 wells and several thousand miles of pipes leading to refining and exporting centres on the Great Lakes and the Atlantic coast. Ohio, Indiana, Texas, and California have increasingly important sources of supply. Fresh discoveries will doubtless be made. As lately as 1901 a very productive region was found at Beaumont, in Texas, less than 20 miles from the sea.

The distillation of petroleum is said to yield 200 different products which are widely used in the industrial arts. The lighter oils, known in the United States as kerosene, are used for lighting, the heavier (American paraffin) for heating and lubricating machinery. Oil fuel for steamers and trains, already used to some extent, has probably a great future. Other products, all highly inflammable, are naphtha, gasolene or petrol, benzene, benzoline, and rhigoline, the latter used to cause local anæsthesia by rapid evaporation. The residuum yields paraffin and vaseline. The former is used in making candles and to insulate electric wires. Ozokerit, a very similar substance of natural origin, found in Galicia and Utah, is put to the same uses.

British paraffin oil and paraffin wax are distilled from bituminous shale near Edinburgh. Similar shales are worked in New South Wales and Queensland.

Natural gas occurs in many parts of the United States, but is commercially important only in Western Pennsylvania and parts of Ohio and Indiana, where it is carried by pipes to the industrial centres. It has special advantages in glassmaking, which has become important in Western Pennsylvania.

Asphalt, used in street paving, can be obtained from petroleum, but its commercial sources are the natural deposits in Barbados, Trinidad, Venezuela, Algeria, the Swiss Jura (Val de Travers) and other parts of Europe.

Iron and Steel. Iron ranks next to coal in commercial importance. Directly or indirectly, it is used in nearly all industrial undertakings, so that the material condition of a country can be roughly estimated by the annual consumption of iron. In the United Kingdom and the United States, it amounts to about 300 lb. per head of the population, against less than 3 lb. in India. Iron is said to occur pure in Greenland, but elsewhere it is mixed with carbon sulphur, phosphorus and other impurities. [See METALS.] The principal iron ores are (1) the black oxide or magnetic iron of Sweden, the Urals, Canada, and the United States; (2) the red or brown hæmatites of Northern Spain, Elba, France, Germany, and the British Isles. In England there are deposits 15, 30, or 60 ft. thick, in the Furness district. The purer carbonates of iron are known as spathic ore, the less pure as clay ironstone and blackband ores. The Eisenerz district of Styria is the chief source of spathic ore. Some spathic ores are rich in manganese, which plays an important part in the Bessemer process. [See below.] The clay and blackband ores are very common in Britain. The sulphides, or iron pyrites, are valuable only for the sulphur they contain, a minute percentage of sulphur being extremely injurious in iron.

The Supply of Iron. Iron is very widely distributed over the world, but the United States, the United Kingdom, and Spain, are the chief sources. The best ores are those of Canada, Lake Superior, Sweden, and Algeria. The chief iron fields of Britain are in the Scottish coalfield, on the Cumberland coalfield, including the Furness district of Lancashire, round the Tyne and Tees, including the Cleveland district of North Yorkshire, on the Yorkshire coalfield, especially round Sheffield, in many parts of the Central Plain, especially on the coalfields, and on the South Wales and Bristol coalfields.

In the United States the Northern Appalachian region (Pennsylvania, New York) has in recent years been passed by the Lake Superior region (Minnesota, Michigan) and by the Southern Appalachian (Birmingham, Ala.).

Iron occurs either at the surface or at considerable depths. The Bell Island mines of Newfoundland are really an open quarry of red hæmatite. Some of the famous iron ores of Lake Superior can be extracted by steam shovels, the daily output of each shovel being from 1,500 to 2,000 tons.

Iron enters into commerce as pig iron, cast iron, wrought iron, and steel.

Iron Smelting. To remove impurities iron must be smelted. Before the use of coal, the fuel was charcoal, but only very pure ores could be used. The iron industry was then confined to forested districts such as the Forest of Dean, in this country, or the Weald, which was gradually deforested by the ironworkers. The black oxide occurs in rocks in which coal is very seldom found, and these ores are still smelted with charcoal in Sweden and Russia, both forest countries. The process is much dearer, but a much better result is obtained. With the introduction of coal fuel the iron manufacture shifted to the coalfields. In our own country coal and iron generally occur together. This is one of our great commercial advantages. Where they do not occur together it is more economical to carry the ore to the fuel, for the equivalent of two tons of coal is needed to turn out one ton of steel. This is profitable only where water transport is available, as in the case of Lake

Superior, Sweden, and Northern Spain. Where long railway freights would be incurred, as with the rich iron deposits of the Rockies, iron, however abundant, is commercially of little value.

Coke, which is relatively free from sulphur, petroleum, or natural gas, is also used in iron smelting.

To extract iron from the ore the latter is smelted, or melted, by intense heat, in blast furnaces with forced draught. The largest furnaces in this country are round Middlesbrough, the centre of the Cleveland district.

Where coal, iron, and limestone occur together a district is ideally situated for iron smelting. This is the case in the coalfields of the Pennines, in this country, and in the Birmingham district of the Southern Appalachians.

The World's Production of Iron. The total quantity of ore to-day extracted exceeds 90,000,000 tons, valued at over £26,000,000. The United States turn out nearly 31,000,000 tons, or over one-third; Germany (with Luxemburg), 17,500,000 tons, or nearly one-fifth; and the United Kingdom, over 13,000,000, or one-seventh. Spain produces 8,000,000 tons, Russia and France about 5,000,000 tons each, and Sweden and Austria-Hungary over 3,000,000 tons.

The world's production of pig iron is about 50,000,000 tons, the United States leading with 23,000,000 tons in 1905, or more than one-third. In 1905 Britain turned out 9,593,000 tons. Half a century ago the United States produced only half a million tons, and this country only 2,225,000 tons.

Wrought iron, which is malleable, ductile, and very flexible, is made by stirring or "puddling" molten pig iron in contact with the air to burn out the carbon.

Steel. Steel is a form of iron in which the small proportion of carbon required seems to enter into chemical combination with the iron instead of being present as an impurity. Steel is harder and stronger than iron and finer in grain.

For ordinary purposes steel is made by one of three processes—the Bessemer process, the Siemens-Martin, or open-hearth process, and the basic process [see METALS]. Where phosphorus is present in the ore the basic process is used, lime being introduced to combine with the phosphorus. This discovery allows the Cleveland ores to be made into steel, and has greatly increased the prosperity of Middlesbrough.

The World's Output of Steel. The world's output of steel exceeds 33,000,000 tons, of which over 14,000,000 tons are made in the United States, over 7,000,000 tons in Germany, and nearly 5,000,000 tons in this country. In the United States the steel industry, formerly carried on almost exclusively at Pittsburg, is now extending north to the southern shores of Lakes Erie and Michigan, where the ores of Lake Superior meet the coal of Ohio and Illinois, and to the Birmingham region of the Southern Appalachians.

Forty years ago, when iron rails were used, only light engines of 25 to 35 tons could be used, and traffic was proportionately slow. Modern engines, running on steel rails, are three or four times as heavy. Steam boilers resist four times more pressure than the old iron ones, so that speed is accelerated while fuel is economised. This has led to an enormous development of railway and steamer traffic, and, generally speaking, to an all-round cheapening of commodities. Great engineering works, such as the Forth Bridge or the bridge across the Zambezi gorge, have been rendered possible. Steel is even replacing timber in the framework of modern buildings, especially in the sky-scrapers of the United States.

Gold and Silver. Gold and silver play an important part in the commerce of the world by serving as the basis of the currency. They have also many uses in the industrial and decorative arts. Both gold and silver are very widely distributed, but many deposits would not pay working expenses. Gold is found in quartz or other rock veins, either pure or in combination. The rock has to be mined, crushed, and chemically treated [see MINING and METALS]. In many regions gold-bearing rocks have weathered, and gold is carried down by the streams, from whose sediment it can be extracted by washing, the lighter matters draining away, and the heavier gold remaining. Roughly done, this process (placer mining) is wasteful, and it is now generally carried out on a large scale by hydraulic apparatus and the use of mercury, which forms an amalgam with the gold.

The discovery of rich placer deposits in the Californian Sierras in 1848 led to a "gold rush." Similar outbreaks of "gold fever" followed the discoveries of placer gold in Australia in the 'fifties, and in the Klondyke in the 'nineties.

The world's output of gold has been increased in the last half-century by these and other discoveries, and by improved methods of extraction. In 1905 it was estimated at 541 tons, valued at £75,000,000. The Transvaal, where the richest auriferous district is the Rand, near Johannesburg, leads with an output valued at about £20,000,000. The United States produce nearly £16,000,000; Australia, £15,000,000; and Russia less than £5,000,000. Canada, Mexico, and India rank next. The British import of bullion exceeds £21,000,000, three-fifths of which comes from South Africa and one-sixth from Australia.

Most of the civilised countries of the world take gold as the standard of value and the basis of the currency. Owing to its extreme softness, it is mixed with silver, iron, copper, or other alloy to give it sufficient hardness. Gold is also largely used in the decorative arts, and is put to some industrial purposes (photography, dentistry). Gold leaf is made by beating out a given quantity of gold till its thickness is inappreciable.

Silver. Silver is generally found in combination with other elements, and very commonly with lead. The whole of the Pacific of North America is argentiferous, Mexico, the United States, and Bolivia leading as silver-producing countries. Mexico produces over 60,000,000 oz., or somewhat less than 2,000 tons. The United States exceeds 55,000,000 oz. Bolivia and Australia both exceed 10,000,000 oz., or 300 tons. The total output of the world is over 170,000,000 oz., valued at over £20,000,000. The value of

silver has fallen rapidly in recent years, being less than 1s. 10d. an ounce in 1902. It has since gradually risen, and stands to-day at about 2s. 6d. an ounce.

Silver forms part of the currency of gold standard countries, and the entire currency of many others. It is used in making plate and jewellery, in other decorative arts, in photography [see PHOTOGRAPHY], etc., and also for electro-plating [see ELECTRICITY and METALS].

Copper. Copper is, after silver, the best conductor of electricity, while it is much cheaper. The demand has therefore increased enormously in recent years. Copper is found either pure, as at Lake Superior and Bolivia, or in ores, the smelting of which presents considerable difficulty, and tends to be carried on at a few noted centres. In the 'sixties, Chile was the main source of the world's copper supply, but it is now surpassed by the United States, which turns out half the world's product of 770,000 tons (1906), valued at about £66,000,000. The most important deposits, besides those of Lake Superior, are in the Rockies. These are continued in Mexico and in the Andean countries—Chile, Peru, Argentina, Bolivia. In Europe the chief mines are in the Iberian Peninsula, especially in the Rio Tinto, and in the Harz. Japan and Australia are also copper producing countries. The chief smelting centres in this country are at Swansea, Widnes, and Glasgow.

Copper is chiefly used for electrical apparatus, for sheathing ship plates, and in the manufacture of brass, bronze, and bell-metal. The increasing demand is leading to a rise of prices, and rumours of a future copper famine.

Lead. Lead is seldom found pure. It generally occurs in the form of galena, which contains a proportion of silver. In Europe, Spain and Germany are the chief sources of supply. Australia yields about one-tenth of the world's output, which amounts to about 870,000 tons, valued at over £11,000,000. In the New World, lead is found in the Rockies, including Mexico, and in Peru and Chile in South America. It is in increasing demand for plumbing, roofing, the manufacture of shot and type metal, and for the manufacture of solder, pewter, Britannia metal, etc. Red and white lead are largely used in the manufacture of paints. The United Kingdom and the United States take more than half of the world's supply of lead, the output of Mexico going to the latter, that of Spain to the former. Great Britain has the largest import and export trade in lead in the world.

Mercury. Mercury, or quicksilver, is a liquid metal, used in making scientific instruments, such as the thermometer and barometer, in gold-mining, medicine, etc. The most famous mines in Europe are those of Almaden, in the Sierra Morena (Spain), Idria, in Carniola (Austria-Hungary), and Northern Italy. In California are the rich mines of New Almaden. Large quantities of mercury are exported from San Francisco to the mines of Mexico and Central and South America.

Tin and Zinc. Tin, though widely distributed, seldom occurs in paying quantities. The mines of Cornwall, the richest in Europe, no longer supply the demands of the home market. At present the chief sources of supply are the Malay Peninsula, and the islands of Banka and Billiton in the Dutch East Indies. Tin also occurs in Australia, and is exported in some quantity from Tasmania. Bolivia is the chief exporting country in the New World. Tin is chiefly used to coat thin sheets of iron (tinplate), from which tinware is made. The South Wales coalfield is largely engaged in the tinplate trade. Tin is also used in making bronze, pewter, and Britannia metal. Zinc is found in various parts of the United Kingdom, but Prussia and Belgium are the chief sources in Europe. In the United States it is found in the States of Kansas and Missouri. It is largely used in making galvanised iron, so extensively used for roofs.

Other Metals and Minerals. The other metals of commercial value are aluminium, obtained by electric processes from bauxite and cryolite. [See METALS.] Aluminium works are commonly near falls (Niagara, the Swiss valleys, the Falls of Foyers in Inverness, etc.), which supply the needful power. For antimony, arsenic, bismuth, chromium, cobalt, manganese, nickel, and platinum, and their uses [see METALS].

Many other commodities belonging to this class might be mentioned if space permitted. Sulphur, used in making gunpowder and matches, in the vulcanisation of india-rubber, and for many other purposes, is obtained either from volcanic districts, or from iron pyrites. Plumbago (graphite, blacklead) is chiefly obtained from Ceylon. Nitrate of soda, a valuable agricultural fertiliser, is worked in the deserts of Northern Chile. Salt, one of the most valuable articles of diet, is found in many parts of the world, either as rock salt, or brine springs. It is also obtained by evaporating sea water [see article on Condiments in FOOD SUPPLY.]

Marble is the most valuable of many building stones. Lithographic stones are obtained from Bohemia. Kaolin, a decomposed granite which derives its name from the Kaoling Mountains of the Chinese province of Kiang-si, is used in making pottery and paper. It is found in Cornwall, France, Germany, and the United States [see EARTHENWARE].

Precious Stones. The most valuable of precious stones is the diamond. Nearly the whole of the world's supply comes from South Africa. Brazil supplies only a fraction, and those of inferior quality. Pearls and mother-of-pearl are obtained from the Persian Gulf, Ceylon, the seas round Australia, and Venezuela. Rubies come chiefly from Burma and Siam. Sapphires are exported from Ceylon, Kashmir, Burma, and Queensland. Opals come from Hungary, Mexico, Colorado, New South Wales, and Queensland. Coral, produced by the coral polyp, is fished in various parts of the Mediterranean.

Continued

RUBBER & RUBBER SUBSTITUTES

Reclaimed Rubber. Three Substitutes for Rubber. Hard Rubber and its Uses. The Chemistry of India-rubber. What Occurs in Vulcanisation. Gutta Percha

THE recovery of rubber is a problem to the solution of which much thought and research have been devoted, and it cannot be said that it is yet adequately solved. The nature of the reaction which occurs between the prepared caoutchouc and sulphur during vulcanisation renders the elimination of the combined sulphur and the reconstruction of the rubber hydrocarbon on a practical basis, which would be the ideal process, extremely improbable, if not impossible. Since this has been recognised, efforts have been directed to the removal of free sulphur and other ingredients, after which the recovered rubber is again worked up, either by itself or with some compounding material, such as fresh rubber.

The Waste Rubber Industry. The large annual consumption of rubber places huge quantities of old or waste rubber at the disposal of the manufacturer. Disused rubber shoes, large quantities of which are received from Russia, form one of the principal sources of raw material; old cycle tyres, and waste cuttings of vulcanised sheet rubber are also largely utilised. To a less extent, too, mechanical goods are employed, such as old hose, belts, and packing. Reclaiming waste rubber is quite a separate branch of the rubber industry to which many large firms devote themselves entirely. They usually have their own special methods of treating the waste material; many innovations and improvements in the processes are, however, constantly being brought out. There are two general methods in use—namely, one which is entirely mechanical, and the other a chemical treatment. Reclaiming rubber was first practised in the United States, where the process consisted merely of boiling the waste vulcanised rubber after it had been reduced to a powder, and then running it into sheets. The general lines upon which operations are now conducted are as follows: The raw material is first carefully graded, according to the quality of the rubber and the extent of oxidation it has undergone through use and exposure. Foreign substances, such as iron, brass, leather, textures, etc., are then removed as far as possible by mechanical means. The material is then ground and treated chemically for the removal of sulphur and fibres.

The usual agents employed to effect this are either acids or caustic alkalies. Neutral sulphite solutions have also been introduced for this purpose. The rubber is then well washed with water and dried, after which it is kneaded on heavy mixing rollers where additions of oil, paraffin, or naphtha are frequently made in order to render it plastic and cohesive, and amenable to treatment on the calenders by which it is rolled into sheets like unvulcanised rubber. The quality of the reclaimed rubber will naturally depend upon that of the raw material employed.

Uses for Reclaimed Rubber. Reclaimed rubber is used chiefly for soles of shoes and for compounding with unvulcanised caoutchouc. The mechanical process, which is not used to the extent of the above chemical method, consists of disintegrating the waste rubber, when fragments of iron are removed by magnets, and textile fibres blown out by treatment in a special apparatus. The powdered rubber is then strongly heated and drawn out into sheets.

Reclaiming Rubber by Means of Solvents. Non-volatile solvents have been found more applicable for the recovery of rubber than volatile solvents. Those principally employed are aniline, toluidine, and phenol, heavy oils, and tar, the chief obstacle encountered being the slight solubility of vulcanised rubber. The method of reclaiming with phenol consists mainly of extracting the finely-powdered waste rubber under reduced pressure. After removal of the free sulphur and separation of the reclaimed rubber, the phenol is recovered by distillation. In another process coal-tar bases, such as aniline, are employed for dissolving the rubber, which is afterwards thrown out of solution in the form of a tough mass by the addition of acid.

The making of rubber substitutes is another question which has long claimed the attention of rubber chemists and manufacturers. Owing to the high cost of rubber, extensive trials have been made to provide an artificial substitute which would have similar, or identical, properties to the genuine article. France achieved the greatest success in this direction and the first rubber substitute emanated from that country, whence products of this description have derived their name of "factice," which is a generic term for all artificial rubber compounds made with vegetable oils. The oil, which is either linseed, rape seed, or cotton-seed oil, first undergoes an oxidation process, and is then either treated with chloride of sulphur or mixed with sulphur and heated.

Three Kinds of Rubber Substitutes. There are three kinds of substitutes — white, brown, and black. Their value lies, when used in moderation, in lowering the cost of the material without deteriorating its quality to any appreciable extent, and for this purpose they possess certain advantages over mineral adulterants and bituminous products. Besides sulphurised oils, many other substances of most diverse natures, including resins, glues, asphalt, and cellulose, have been tried for producing a good substitute. Two or three compositions may be worth mentioning. Blandite, invented by Dr. Blandy, is an artificial india-rubber of fair elasticity; it is vulcanised like the ordinary rubber, and can be moulded. Its constituents are oxidised linseed oil to which a 10 per cent. solution of chloride of sulphur in carbon bisulphide is added with gentle heat; one part of the oil is then mixed with three parts of Trinidad asphalt, the whole being gradually liquefied by heating and stirring, after which it is run into sheets.

Fenton's artificial rubber is a product patented by F. Fenton and manufactured from linseed or similar oils, which are mixed with tar or pitch and submitted to the action of dilute nitric acid, until the whole coagulates into a tough elastic mass. Further treatments with solutions of nitrates are recommended, and after vulcanising, "Fenton rubber" is said to resist a temperature of 320° F. without its elasticity being impaired.

Parkesine, Rubberite, and Textiloid. *Parkesine* is a proofing and moulding compound. It is prepared by treating cotton rags with sulphuric acid, the acid being subsequently neutralised with carbonate of soda. After being washed and dried the product is reduced to powder, and then may be used for compounding with fresh rubber, or as a proofing compound mixed with 10 to 20 per cent. of linseed oil. *Rubberite*, invented by H. C. B. Graves, consists largely of Trinidad asphalt and oxidised oil, with small proportions of vaseline, sulphur, and chloride of sulphur. In colour, elasticity, and durability, it is said to resemble the higher grades of rubber. *Textiloid*, another proofing substitute, is a mixture of resinoline, cellulose, and camphor; it is odourless, practically non-inflammable and very elastic.

There are a large number of compounds constituted in a similar way to the above with slight alterations and the introduction of certain specific substances which are intended to produce products having the essential characteristics of rubber.

Special Uses for India-rubber. Besides the large number of purposes to which india-rubber is put, and which readily occur to the mind, there are one or two others less well known in which it is none the less valuable. As a floor covering it has been used for many years with excellent results, and its wearing properties are remarkable. Rubber tiling has been known, when laid in juxtaposition with flagstones, to require cutting down to the level of the latter after several years' wear. Rubber tiling for offices is laid in a variety of patterns, and as it always presents a very good surface it is easily cleaned. Figure **14** shows the method in which the tiling is laid.

A compounded floor covering, known as kamptulicon, is made from vegetable fibrous materials, which are ground into a coarse powder, then mixed with india-rubber, and treated with a cheap solvent; other substances may also be incorporated, such as reclaimed rubber, ground cork, and cheap grades of gutta percha.

Cements of great variety are made from rubber, being largely used in the leather industry, and also for cycle tyres. The rubber is dissolved in solvents, the nature of which is determined by the purpose for which the cement is required, all manufacturers having their own special formulæ.

Hard Rubber. The invention of hard rubber, vulcanite, or ebonite is due to Goodyear, although many investigators have studied the product, with the result that improved methods of manufacture, producing more satisfactory results, have since been introduced. Its manufacture is, on the whole, based on the same lines as for the production of soft rubber goods, the essential difference lying in the increased amount of sulphur used. The raw rubber is washed, dried, masticated, and compounded with suitable ingredients. The sulphur added sometimes amounts to 60 per cent.; more than 50 per cent., however, is inclined to make the product brittle. The quantity of sulphur present also regulates the degree of hardness, which increases proportionally according to the amount of sulphur added.

Sulphide is sometimes substituted for the sulphur, and other compounding materials are also frequently incorporated on the mixing rollers to impart certain characteristics in colour, texture, or flexibility. Those chiefly employed are whiting, zinc white, magnesia, resins, and sulphides of mercury and antimony. Great care must be taken that the materials be thoroughly dry, because if any moisture be enclosed during the mixing, steam would be evolved in the subsequent vulcanising operations, and this would render the goods porous, a very objectionable trait.

Vulcanising Hard Rubber. The prepared material is drawn out into sheets in a similar manner to ordinary rubber, and from these articles are accordingly fashioned. Metal or textile insertions are rarely used, as there is very little call for them. The goods are usually vulcanised in moulds; tubes in the same way as soft rubber tubing—namely, on their metal core, and bound up with cloth. The boilers and presses employed for vulcanising hard rubber goods are the same as for soft rubber, but a considerably higher temperature is required. The process is usually started at about 250° F., and is gradually raised to 300°, 320°, or even 330° F. The time, of course, depends largely upon the dimensions of the articles, and the composition of the rubber, and varies from six or seven hours to as long as ten or twelve hours.

Characteristics and Uses of Hard Rubber. The physical properties of hard rubber are quite at variance with those of soft vulcanised rubber. It is of a black colour, without smell, and may be compared to horn, hard wood, or even ivory in texture. Ordinary atmospheric influences do not affect it; it does not oxidise nor change in cold water, but in boiling water it softens somewhat, so that it can be bent. It is a non-conductor of electricity, and is not dissolved nor influenced by the ordinary solvents of rubber; acids also have little action on it. On being heated to about 400° F., ebonite carbonises without passing through any intermediate melting stage.

As this material can be easily worked with all kinds of cutting tools and also takes a fine polish, it is much appreciated for the manufacture of fancy goods, as well as being largely employed for technical purposes. It is used for the production of a great number of small articles, ornaments, and imitation jet, and when given a specially fine polish it serves to imitate onyx. To assist polishing operations, which are usually done on a lathe or by polishing discs, the moulds in which the compounded rubber is vulcanised are made of glass, or if of iron they are lined with tinfoil. One of the most important uses for which hard rubber is indispensable is the manufacture of certain parts of electrical machines, insulating appliances, and accumulator cases. For photographers' developing dishes, tubes, taps, and other adjuncts for chemical laboratories, hard-rubber is specially serviceable.

Semi-hard Rubber. An intermediate product, called *semi-hard rubber*, is manufactured for certain purposes where greater elasticity or flexibility than hard rubber possesses is required. More sulphur, however, is employed than for soft rubber goods, and vulcanisation is carried out at a higher temperature, and for a longer period, but care must be taken not to go too far in these three particulars, otherwise hard rubber would be produced; in fact, they must be moderated according to the exact degree of hard or soft rubber which it is desired to produce. This kind of rubber is used for lining acid vats, for making large cylinder covers, and for many other purposes of a technical nature.

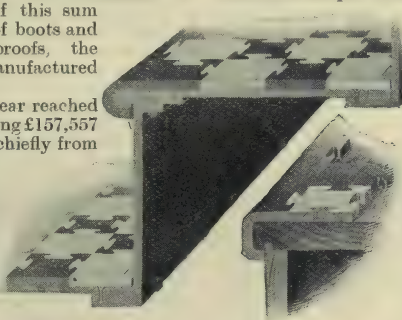
Another branch of the hard-rubber industry is the preparation of unvulcanised caoutchouc for dentists' purposes. The rubber is specially compounded to produce vulcanite of the desired shade and texture; it is then sold to the dentist, by whom it is cured and finished.

For the decoration of articles made of hard rubber, pigments mixed with shellac are applied by brush. A hot plate is then forcibly pressed against the surface, so that the colour becomes inseparably fixed.

Substitutes for Hard Rubber. Many substitutes for hard-rubber, made from cellulose, gums, and various other substances of animal, vegetable, and mineral origin, have been devised, but none approach the original article. To mention two: (1) *Kiel compounds*, which are compositions of india-rubber, sulphur, pumicestone, oil and beeswax. When vulcanised, this compound withstands immense cold; it resists acid, is an excellent insulating material, and is also cheap; it can, moreover, be worked with greater ease than hard rubber. (2) *Vulcanised fibre*, which is manufactured from cotton paper pulp that is dissolved chemically, and solidified under great pressure. It is made in two forms—hard and flexible; the hard fibre is very tough, and strong like horn. In dry places it can be used as an insulator, and is not affected by oils or fats.

Exports and Imports of Rubber Goods. The total exports of manufactured rubber goods of both British and foreign make from the United Kingdom in 1905 amounted to the value of £1,865,642. Of this sum £249,212 represent the value of boots and shoes, and £227,893 waterproofs, the balance being other sorts of manufactured rubber articles.

The imports for the same year reached the figure of £846,400, comprising £157,557 for boots and shoes, received chiefly from Germany and the United States, and £5,681 for waterproofs, leaving £683,162 for other kinds of goods.



14. METHOD OF LAYING RUBBER TILING
(A. L. Gibson & Co., London)

The Chemistry of India-rubber. The colloidal nature of india-rubber occasions great difficulties in its chemical investigation, since, unlike bodies of a crystalloid character, compounds belonging to this class have no definite characteristics as melting points, boiling points, and definite solubilities, but pass gradually from one state to another. Accordingly, their separation from mixtures and their purification is attended with great difficulties. Being derived from a variety of trees, shrubs, and vines, it is not surprising that the chemical composition of commercial rubbers varies to a considerable extent. Impurities, such as sand, vegetable matter, fibre, etc., are removed by washing, but the water also carries away certain sugars from the rubber, although these are present only in small quantities, rarely exceeding 0·5 per cent. After the washing process the rubber is by no means a chemically pure product; it is, however, regarded as technically pure. It contains certain oily and resinous substances which can be extracted by solvents such as alcohol or acetone. The quantity of these resinous substances ranges from 1 per cent. to about 40 per cent. Their nature also varies with different brands, from an oily extract through different degrees of viscosity to resins resembling colophony; sometimes they are even of a white, powdery nature. Small quantities of albuminous matters also occur in crude rubber, especially when the latex has been coagulated by heat, by chemicals, or by drying. If the latex were to be coagulated by centrifugal means, these substances would be almost completely eliminated. Exact information regarding the amount of these albuminous substances in rubber is wanting, but from investigations on the latex it is assumed that they would amount to about 5 per cent. in dry rubber. Their removal on a commercial scale is practically impossible. The elementary composition of india-rubber, deducted from the investigations of many chemists prior to 1888, is $C_{10}H_{16}$.

Impurities of Crude Rubber. Of recent years further researches have revealed the presence of an insoluble constituent in rubber, and this subject has been carefully investigated by C. O. Weber. He found that this insoluble body possessed different physical properties to india-rubber, as it was not sticky, nor adhesive, though very tough when dry; it was further only moderately distensible. This body having been found to contain a considerable amount of oxygen, it is inferred from its chemical composition by this investigator that it forms a link between the india-rubber hydrocarbon and the complex carbohydrates (sugars) which are assumed to be the raw material from which the plant produces caoutchouc. That it is not a simple oxidation product of india-rubber is inferred from the elementary analysis of oxidised rubber, or Spiller's resin, to which it does not entirely conform. All rubbers appear to contain this body, but as the quantities are generally very small its presence is of much more interest scientifically than commercially, although it is suggested that certain irregularities observed in the vulcanisation process may be due to the presence of this insoluble constituent.

There is one other impurity always present in rubber, and that is a small percentage of mineral matter, generally described as ash. The amount is very equable for all commercial brands of india-rubber and is generally below 1 per cent., though some kinds contain as much as $2\frac{1}{2}$ per cent. It is hardly possible as yet to assign the origin of a rubber from the constitution of its ash, but it is stated that lime predominates in Para rubber, ferrous salts in African rubbers, and magnesia appears to be a characteristic of Ceara rubber.

Synthetical Rubber. It has long been known that caoutchouc could be produced synthetically, because Professor Tilden stated, before the British Association in 1882, that it had been prepared from isoprene. The hydrocarbon isoprene, besides being one of the results of the dry distillation of caoutchouc, can also be separated from turpentine, colza oil, linseed oil, and castor oil. By allowing one part of isoprene to stand in contact with 15 parts of hydrochloric acid, then diluting with water and evaporating, a solid residue, which has analogous properties with india-rubber is obtained. The isoprene may also be exposed to light for a few months, when the formerly colourless liquid is converted into a thick syrup containing yellow flakes or lumps of rubberlike substance, which have been pronounced by scientists to be synthetically produced india-rubber. As considerable

time is required, and the price of the raw materials would have to be low, the cost of *synthetical rubber* is naturally high, being from 200 to 300 times as great as natural rubber. Further, it is quite possible that the cost of producing the latter may be reduced in the future, so that there is no present prospect of the synthetical article having more than a scientific importance, at any rate for some time; and since the first announcement that it could be produced synthetically little advance has been made in the direction of the reduction of its cost.

Destructive Distillation of India-rubber. When pure india-rubber is subjected to destructive distillation three definite compounds can be isolated from the distillate—namely, isoprene, boiling from 98° to 100° F.; caoutchene, boiling at 338° F., and heveene, with a boiling point of 600° F. All these bodies have the same percentage composition as india-rubber (polyprene), but investigations indicate that they do not exist as such in india-rubber; but upon distillation a change is effected in the structure of the hydrocarbon with the formation of the three above-mentioned bodies, and, as previously stated, india-rubber may be formed by the polymerisation of isoprene under suitable conditions, although certain terpene compounds are produced from it at the same time to a considerable extent.

Dipentene, or caoutchene, is the chief product of the dry distillation of india-rubber; it may also be obtained in a variety of ways from certain terpenes or their derivatives. After heveene, the distillate consists of hydrocarbons boiling at a temperature over 600° F. Their percentage composition, however, still corresponds to that of india-rubber, and the amount of carbon remaining behind is so extremely small as to suggest that it arises from albuminous and other impurities. The quantities in which these products are produced vary according to the way in which distillation is carried out, but their respective yields are approximately as follows: isoprene, 5 per cent. to 6 per cent.; dipentene, 40 per cent. to 46 per cent.; heveene, 12 per cent. to 17 per cent.; polyterpenes, 26 per cent. to 38 per cent.; carbon residue, 2 per cent.; mineral impurities and water, 2 per cent. Little is known regarding the actual changes which take place during distillation. Whether the india-rubber molecule splits up at a given point with the formation of one or all of the above bodies, or the process is gradual still requires investigation, and probably much could be learnt from a close examination of the changes that take place during distillation. Different brands of rubber soften and liquefy at different temperatures, but they all yield the same series of products on being subjected to dry distillation.

Chemical Reactions. India-rubber is a colloidal substance, which in chemical indifference almost rivals the solid paraffins. The action of the halogens upon caoutchouc dissolved in chloroform is interesting. Chlorine acts very energetically, forming an addition and substitution product, the constitution of which agrees with the formula $C_{10}H_{14}Cl_8$. With bromine the action is less violent, a very indifferent product, corresponding to the formula $C_{10}H_{16}Br_4$, being formed. Investigations upon this compound have contributed considerably to the knowledge of the composition of india-rubber. On the addition of iodine to a solution of caoutchouc in chloroform, an addition product, $C_{10}H_{16}I_3$, is formed, but only very slowly. Similarly with the halogen acids, hydrochloric acid has the strongest action, forming the dihydrochloride from which the monohydrochloride is formed by hydrochloric acid being split off. Hydrobromic acid has a like action, but somewhat slower, while hydriodic acid has apparently no action. Sulphuric acid chars and oxidises india-rubber, but nothing is known regarding the constitution of the resultant products. Nitric acid has a very vigorous action upon india-rubber, a yellow body being first formed, which subsequently decomposes into nitrogen, oxalic acid and a product of the character of fat. Nitrous acid, in the absence of water, forms a compound corresponding to the formula $C_{10}S_{16}N_2O_3$, apparently polyprene nitrosite; upon the action of this acid a method of determining the value of crude rubber is based. The influence of oxidising agents upon india-rubber has never been systematically studied. Spiller isolated a product containing 27·5 per cent. of oxygen, and the substance known as Spiller's resin is a form of oxidised india-rubber.

What Occurs during Vulcanisation. The action of sulphur upon india-rubber—that is to say, the process of vulcanisation, has been investigated by a large number of chemists. Burghardt and Payen have regarded the reaction as one of substitution of sulphur for hydrogen. Donath has expressed the opinion that the vulcanisation process is one of molecular aggregation, somewhat comparable to metallic alloys, rather than the result of chemical combination. The reaction taking place when india-rubber is treated with a solution of chloride of sulphur has been made the subject of research by J. Minder, who presents the view that the solvent has a softening effect upon the rubber, which then absorbs the sulphur. Some maintain that substitution of sulphur for hydrogen takes place, the hydrogen going off in the form of hydrochloric acid; others that the chlorine effects vulcanisation. Weber has given a large amount of attention to the subject of vulcanisation, and states that before an exact knowledge of the process is acquired, elucidation of the colloidal state of rubber from a chemical point of view is necessary. Colloids are capable of being converted into what is known as the *pectous* condition. In this state they are much more indifferent chemically and physically. The change is brought about by various means according to the nature of the colloid—thus, on heating albumen with water it coagulates, or pectisation takes place. This state, which colloidal matter can be made to assume, plays an important part in the vulcanisation of rubber.

The Theory of Vulcanisation. It has been conclusively demonstrated by Weber, from an exhaustive series of experiments carried out on Para and other brands of rubber, that chemical combination does take place between the sulphur and caoutchouc with the formation of polyprene sulphide. As there is practically no evolution of sulphuretted hydrogen during the vulcanisation process, this must be regarded as an addition product and not one of substitution, in which sulphur takes the place of hydrogen. It was found, however, that the insoluble constituent of rubber (which does not exceed 5 per cent. of the technical product) when heated with sulphur does give off a considerable amount of sulphuretted hydrogen, due to the formation of a *substitution* product. The combination of sulphur with polyprene does not apparently take place in definite stages, the extent of combination being determined by time, temperature, and the amount of sulphur present. Experiments with hard rubber, however, showed that a definite amount of sulphur—namely, about 32 per cent., enters into

combination, even when a considerable excess over this figure has been incorporated. Then, on continuing the vulcanising process, more sulphur was made to combine, but with evolution of sulphuretted hydrogen, showing that one of substitution was taking place. From this it is concluded that 32 per cent. of sulphur is the upper limit for the formation of addition products, and corresponds with polyprene disulphide with a formula of $C_{10}H_{16}S_2$. No exact data being obtainable regarding the lower limit for the formation of sulphur addition products, the amount of sulphur necessary for producing a well-cured rubber may be taken as a guide; this is from 2 per cent. to $2\frac{1}{2}$ per cent., and it is extraordinary to find that this agrees fairly well with the formula $C_{100}H_{160}S$., which would contain 2·35 per cent. of sulphur. From this, Weber concludes that "the process of vulcanisation consists in the formation of a continuous series of addition products of polyprene and sulphur, with probably a polyprene sulphide, $C_{100}H_{160}S$, as the lower, and $C_{100}H_{160}S_{20}$ as the upper limit of the series. Physically, this series is characterised by the decrease of distensibility and the increase of rigidity from the lower to the upper limit, which term of the above series—which degree of vulcanisation is produced—is in every case only a function of temperature, time, and proportion of sulphur present."

Physical Characteristics of Rubber. When rubber is worked for a considerable time on the rollers, it becomes *fatigued*, although it will return to its original state to a great extent on keeping. In the fatigued condition it requires more sulphur for vulcanisation; the resultant product does not differ chemically, but its physical aspect is changed. Accordingly, to again quote Weber, "the physical state of the india-rubber colloid while under vulcanisation largely determines the physical constants of the vulcanisation product." This has an important bearing upon the reclaiming of rubber.

Researches upon vulcanisation with chloride of sulphur have proved that addition products are formed analogous to those obtained by vulcanisation with sulphur. The upper limit of the chlorosulphides, as they are termed, is a compound corresponding to the formula $C_{240}H_{348}S_{48}Cl_{48}$, and the lower limit $C_{240}H_{348}S_2Cl_2$. The chemical properties of these chlorosulphides are not affected by the strength of the solution nor by the nature of the solvent in which they are formed, but both these factors have a considerable effect upon their physical characteristics, and this affords a clue to many perplexing facts observed in the cold vulcanisation process.

Cause of "Blooming." In course of time, vulcanised rubber becomes covered with a fine, greyish deposit, sulphur eventually crystallising on the surface. This is technically known as *blooming* or *sulphuring up*, and microscopical examination has shown that the excess of sulphur is distributed throughout the vulcanised rubber in extremely minute globules. In time, crystallisation of the sulphur at the surface takes place, and spreads from globule to globule. The only way of prevention would be to induce crystallisation of the excess of sulphur in the centre of the rubber. It is curious that sulphuring up is unknown in ebonite, although it frequently contains 15 per cent. of free sulphur; it is assumed, therefore, that a state of solid solution exists between the polyprene sulphide and the sulphur in this material.

Further particulars regarding the chemical characteristics of india-rubber, the explanation of its indifference to the sulphur in the cold, and the extraordinary vigour with which it is attacked by chloride of sulphur, the action of chlorine in promoting the "cold cure," etc., are detailed in Weber's "Chemistry of India-rubber."

Valuation of Rubber. The quality of crude rubber is more frequently judged from its appearance, consistency, and the application of a few ready physical tests, for which considerable experience is required, than by chemical analysis. The chief determinations made in a chemical examination are loss on washing, the amount of oily and resinous substances, and the percentage of oxygen combined with the rubber and ash. The testing of manufactured rubber is more extensive, and a complete chemical analysis is a very tedious and complicated process. This, however, is seldom required, and often it is sufficient to subject the goods to physical tests only, of which the most important are the specific gravity, tensile strength, elongation test, sun-cracking and oxidation test, and electrical tests. These tests, of course, are applied according to the nature of the manufactured goods. An ordinary chemical analysis is confined to the determination of india-rubber, organic constituents not rubber, sulphur (free and combined), chlorine and inorganic constituents other than chlorine and sulphur.

Gutta Percha and Balata. Gutta percha is obtained from certain trees appertaining to the botanical family *Sapotaceæ*, which are found growing wild in the Malay Archipelago. The original gutta percha tree, Dichopsis gutta, or Palaquium, or Isonandra gutta, is almost extinct, its place having been taken by the Palaquium or Dichopsis oblongifolium, which yields excellent gutta. Three other varieties, namely, Palaquium Borneense, P. Treubii, and P. Vrieseanum, also supply gutta of very good quality. Less fine gutta percha is obtained from the Dichopsis Calophylla, D. Selendit, D. Krantziana, the two latter yielding a hard product unsuitable for cable insulation. Mention must also be made of two other gutta-producing trees—*i.e.*, Payena Lerii and Bassia Parkii. Native methods of collecting the latex are ruinously extravagant, the trees usually being felled; it has now been found, however, that gutta percha can be extracted from the leaves and twigs of the trees by means of a suitable solvent, such as toluol. The manufacturing process for gutta percha consists of kneading and washing operations. Its most important application is for insulating submarine and other cables, as its resistance to the electric current is unequalled by any material of a similar nature. Certain plants Mimusops balata, M. globosa, and M. electa, also belonging to the *Sapotaceæ* order and found in the north of South America, yield a hornlike substance, resembling, yet distinct from, gutta percha. This material, *balata*, is largely used for the manufacture of driving belts, for which it is excellently adapted, being very tough and inelastic, although liable to become sticky if heated. The process of manufacturing balata belts is essentially the same as described under Rubber Belting, with the exception that no vulcanisation is needed.

RUBBER AND GUTTA PERCHA *concluded; followed by* BASKET-MAKING

continued from page 5190

FISH AND THE FISH-MARKETS

Immature Fish. Artificial Hatching. Diseases of Fish. Preparing Fish for the Market. Oyster Culture. Fishery Laws

By Dr. J. TRAVIS JENKINS

IN many methods of fishing, notably in *shrimping*, large numbers of undersized fish are caught, and in many instances these immature fish are unmarketable. Every haul with the shrimp-trawl in our inshore waters brings up, in addition to the shrimps, a number of small plaice, dabs, soles, herring, codling and whiting; the number of species varying according to locality and season.

Protection of Immature Fish. These fish are unmarketable, but if allowed to remain in the sea a proportion would presumably become of marketable size and be captured by the fisherman. If the shrimp trawls are hauled at short intervals and the net rapidly cleaned and the young fish promptly returned overboard, it is certain that a very large percentage of the flat fish would be uninjured, and they may be seen swimming away as soon as they are replaced in the water. With regard to the round fish it may be said that they are far more susceptible to injury, and extremely prompt measures are requisite to secure that any reasonable proportion be returned to the sea alive. There can, therefore, be no reasonable doubt that many millions of undersized fish are captured by shrimpers in their trawl-nets, push-nets and shanks; and formerly a very large proportion of these were destroyed. The process of separating the shrimps from the fish and other *debris* caught in a trawl is accomplished by *riddling*, and where such riddling is promptly done and the debris and fish returned overboard immediately, little harm is done. Of course, the shrimper naturally selects ground where shrimps are most abundant, and the young fish are caught accidentally; and in this respect the shrimper differs from the whitebait fisherman, who intends to capture undersized fish, for which he readily finds a market.

How to Stop the Needless Destruction of Fish. Where there is a market for undersized or immature fish, though it might be advisable to have the fishery carried on within reasonable limits, since obviously a certain proportion of adults must survive to propagate their kind, it would be as absurd to prevent it altogether as it would be to stop the sale of veal or lamb.

But in cases where the fish are caught accidentally or sold for manure or needlessly destroyed, prompt measures are necessary for the maintenance of the fishery; and where destruction is of a gratuitous nature there can obviously be no sympathy with the person responsible for the damage, though at the same time where he is carrying on a bona fide business it becomes necessary to interfere with him as little as possible.

The most practicable method of dealing with a problem of this kind is to interfere as little as possible with the implements of fishing, but to see that they are not needlessly destructive, and in any case to see that they are used in a proper manner. The prevention of landing of fish under a certain size would effectually stop the fishing *for* undersized fish as distinguished from shrimping, where the undersized fish are accidentally present. Various enactments have been proposed for dealing with this evil, which is admittedly serious. Bill after Bill has been introduced into successive Parliaments, but not being party measures they have had no chance of being passed. But in the territorial waters local regulations, confirmed by the central authority (the Board of Agriculture and Fisheries), have dealt with, and, to some extent, undoubtedly checked, this wholesale and wasteful destruction. The fixing of a size limit below which fish could not be landed would effectually stop the fishing for undersized fish which goes on at present. The protection of the immature fish in the territorial waters may well be left to the local authorities.

Artificial Hatching and Rearing of Marine Food-fishes. A certain section of scientific experts, being firmly convinced that a depletion of the seas was in operation, suggested that man might, by artificial hatching and rearing of the fry of economic fish, restore the balance of Nature. The initiative with regard to the erection and equipment of marine hatcheries is due to the United States authorities, who regarded this plan as more suitable than attempting to prevent the destruction of immature fish by restrictive legislation—an alternative method which had been suggested as a remedy for over-fishing and its evil consequences. The whole *modus operandi* of the marine pisciculturist is, we believe, based on fallacious reasoning. But this is not the place to enter into destructive criticism of his efforts; we are merely content to describe what is claimed to have been done.

1,500 Million Fish Hatched. The United States Fish Commission during the year 1902 claim to have hatched and liberated nearly 1,500,000,000 fish fry, the principal salt-water fish dealt with being cod, flounders and lobsters. The Canadian hatcheries deal mainly with cod and lobsters. The European countries which have adopted artificial hatching are Norway, Scotland and England. The methods in vogue for obtaining fish eggs vary in the different establishments, but in England the mature fish are obtained by trawling from a special steamer some months before the spawning season begins. These fish are kept in tanks or open-air ponds attached to the hatcheries, and are claimed to constitute a reserve of spawners. The eggs are artificially fertilised and then placed in the hatching-boxes, there to undergo their incubation.

The hatching-boxes are kept in constant motion by an automatic arrangement, and a current of sea water is maintained through the boxes. This serves the double purpose of oxygenating the eggs and preventing their settling. Up to the present no successful attempts have been made to rear the fish, the fry being set free a few days after hatching, or never later than after the absorption of the yolk-sac. These larvæ are (or should be) liberated on the off-shore spawning grounds, their natural habitat. No satisfactory evidence has yet been adduced that sea-fish hatching is an

economical success. Originally it was doubtless worth an extended trial, but until rearing the fish as well as hatching them has been accomplished one must reserve one's opinion as to the efficacy of this method of replenishing the sea.

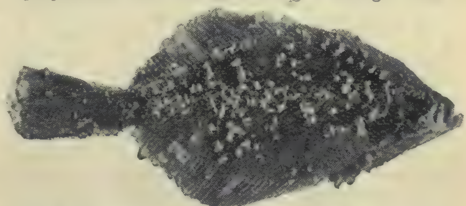
Fish Diseases and Parasites. Fish, like other animals, are subject to "the ills that flesh is heir to," but the alarmist statements that have of recent years appeared in the public Press are quite without foundation, and it may once for all be said that no article of diet can be regarded as so absolutely free from disease as sea fish. The complaints from which fish suffer may be grouped under two headings; firstly, the attacks of parasites, either attached to the body externally (*ectoparasites*), or dwelling in the inside of the fish's body (*endoparasites*); and secondly, infectious diseases due to the presence of vegetable organisms (*bacteria*) or animal organisms (*sporozoa*). Of course, both bacteria and sporozoa are, strictly speaking, endoparasites.

The important question as to how far, if at all, the communicability of diseases from fish to man or vice versâ is possible merits a brief notice. It is perfectly obvious that this question of the purity of fish as a food supply has the most important practical bearings, and the recent "scare" with regard to the connection of oysters and typhoid is a case in point. That shellfish may, under certain extreme circumstances, be the means of communicating such a disease as enteric or typhoid fever to human beings seems to be well established, and not only oysters, but mussels and—though less certainly—cockles may occasionally be held responsible. This is, however, never due to the fact that the oyster is itself "suffering" from the complaint, but rather that the typhoid bacillus is accidentally present either in the food of the oyster or in the sea water enclosed in the shell. Modern research tends to prove that if reasonable care be taken in the selection of the site for bedding oysters, and if ordinary cleanliness be secured in the handling and preparing of the bivalve for the market, the risk of pollution is infinitesimal and certainly not greater than is the case in many other articles of consumption, notably milk. The danger is reduced to vanishing point if the shellfish be thoroughly cooked.

Fish and Human Diseases. Within the last few years considerable attention has been devoted to the study of the diseases of fish, and a review of the literature devoted to the subject is rather a source of satisfaction than dismay. The diseases such as smallpox, phthisis, and dropsy, which have been popularly attributed to fish, disappear or become something quite different on closer inspection.

Fish, however, are undoubtedly attacked by such parasites as thread-worms, tape-worms, and leeches. The *worms* are generally found in the intestines and are removed with them. Leeches are rare and drop off when the fish are caught. Certain *crustacea* (parasitic copepoda) attack fish and are found attached to the gills, fins, eyes, and even in the nostrils. They, however, in most cases, only cause a temporary inconvenience. There remains, then, a few diseases attributable either to bacteria or sporozoa. An instance of the former is the well-known *salmon disease*, which was formerly thought to be due to a fungus (*saprolegnia*). An instance of the latter is shown in the figure of the flounder [14]. In all cases where a fish suffers from complaints of this kind the body is unsightly, being marked with blotches or swellings which would immediately cause it to be rejected for food. In conclusion, though isolated instances of fish (chiefly fresh-water species) suffering from disease are, from time to time, recorded, in no case is the disease identical with any human complaint, and in every case spots or swellings are visible which would render the fish unmarketable. Nothing is said about unwholesome fish where the deterioration is due to the fish having been kept too long; naturally, fish, like other perishable articles, require to be eaten in as fresh a condition as possible.

Preparation of Fish for the Market. Fish, if not speedily placed on the market, deteriorates rapidly, and hence we find a large number of methods of preservation. All these methods depend for their efficacy upon the necessity of eliminating the action of the bacteria responsible for the putrefactive changes which so rapidly take place. A second and most essential purpose to be borne in mind is the preparation of an article which shall at the same time be palatable and be capable of retailing at a reasonable price. The methods of preserving fish fall under four main heads—namely, by *ice*, *salt*, *smoke*, or *canning*. It must be understood that these methods are not absolutely distinct; a fish may, in the course of preparation for the market, go through two or



14. FLOUNDER ATTACKED BY A SPOROZOAN PARASITE

more of these methods in succession. A description of the multitudinous modes of manipulating the raw material would fill the pages of a considerable volume, and therefore the only accounts given here are those which are practicable on a small scale. *Canning*, which requires special plant and is quite distinct from fishing proper, is not touched upon.

The "Finnan Haddies." There are, broadly speaking, three essential stages in the preparation of "finnans." These are splitting, salting, and smoking. The operation of *splitting*, to be rapidly and efficiently performed, requires actual practice. The head is removed, the fish split down the back and eviscerated. It is then *salted* for about half-an-hour in strong brine, then drained, and afterwards smoked. The smoking is now carried on in small houses built for the purpose, the fish being spread open and suspended in tiers. The fuel used is peat, and the operation is continued without interruption for from four to six hours, during which period the fish requires constant attention. The fish are generally put up in boxes of the average weight of 40 lb. The barrels are about four times as heavy. For export purposes "finnans" are *canned*, but as these fish must be cooked, or at least boiled, before canning, in addition to the processes above described, it seems a misnomer to call them "finnans." In addition to finnans there are other varieties of prepared haddocks, notably "smokies," where the fish are smoked over a hot

fire, with abundance of smoke, until they have taken a golden colour; and "pale smoked haddocks," where the fish are but slightly smoked for immediate consumption.

The Preservation of Herring. The four chief methods of preserving herring are best enumerated under the headings by which the resulting product is known to the public—namely, *pickled herring, kippers, bloaters* and *reds*. The *bloater* is intended for immediate consumption and may be described as a round or unsplit herring which has only been slightly salted and smoked. The fish, as soon as possible after capture, are dry salted for from six to twenty-four hours—the time being longer if the fish be fat—and afterwards smoked. The *red* is generally prepared for foreign consumption, and large quantities are exported to the Mediterranean. For this trade the herrings are salted in brine for about two days and then smoked for a fortnight. The wood and sawdust used is of the "hard" variety, and from this the peculiar flavour of the red is derived. The red may be defined as a round herring, heavily salted, and smoked for a long time. They are packed chiefly in barrels and half-barrels, the former containing from about 500 to 600 fish.

Kippers and Pickled Herrings. *Kippers* are first of all split and eviscerated, then salted in strong brine for from a quarter of an hour to an hour, then spread out and smoked over hardwood shavings. The time of smoking varies, being longer at Yarmouth than at Aberdeen. *Pickled herrings* are more numerous than all the other varieties put together. These fish have their gills and intestines removed. They are then brine-salted and packed in barrels and half-barrels. In Scotland these herring may be tested by the Fishery Board. If the merchant desires a certificate of the quality of the fish in his barrels, an officer of the Board opens and examines samples of these barrels, and if the contents come up to the required standard a brand is burned into the head of the barrel. A barrel generally contains 300 lb. of herrings, and each barrel is packed with great care, with alternate layers of fish and salt.

Fish Markets. Broadly speaking, the marketing of fish is left to a special class of individuals—fish auctioneers and salesmen. Even fresh fish is rarely disposed of by the fisherman himself, and the bulk of preserved fish and fish products he never sees.

Fish that is landed at any of the larger fishing ports, such as Hull, Grimsby, Billingsgate or Aberdeen, is sold by auction on the quay. The fish is sorted into baskets or other receptacles, or may even be spread out on the quay floor as at Aberdeen, and the sale is invariably held by auction at an early hour in the morning.

Even fish that is landed by smaller boats at the quieter fishing ports is, to a very large extent, sent to large centres to be disposed of by auction, some occasionally even returning over the same ground for local consumption. The marketing of fresh fish is now such a special occupation that there is a considerable amount of truth in the complaint of visitors to seaside resorts, like Llandudno or Tenby, that they have to wait for the train from Grimsby before they can procure any fresh fish. Many markets for preserved fish are met with abroad, pickled herrings being an especial favourite with the Latin nations.

Oyster Culture. On the Continent *oyster culture* forms a considerable industry, absorbing a large amount of capital and affording employment to thousands of people; but in England, for various reasons, this industry has not been developed to the same extent. The success of oyster culture depends to some extent, as for instance at Arcachon, on the natural physical advantages of the locality. At Arcachon there is a large inland sea of about 30,000 acres area, which communicates with the sea by means of a narrow entrance, through which the tide ebbs and flows. In this lake the oyster reproduces itself naturally. The young stage of the oyster, known as the *fry* or *spat*, is of microscopic size, and swims about in the water for a time, and eventually settles down on suitable objects, there to develop into an adult oyster. [See NATURAL HISTORY, page 3286.]

Spatting. The success of oyster culture depends upon the simple fact that the spat can easily be collected upon suitable objects. The oyster reproduces itself in spring or early summer, and the free-swimming stage lasts for about a week. At the time settling-down process begins, receptacles or collectors are placed in position. The Romans used bundles of twigs; the Dutch use earthenware tiles; in France the collectors are crates of similar tiles coated with a cement of lime and sand, which offer a convenient adhesive medium for the *spat*. The tiles are arranged in rows inside large cases, and in Arcachon alone about 12,000,000 tiles are annually laid down for this purpose. The spat is left on the tiles until the following October, when the young oysters are about the size of a finger-nail, at which stage they are known as *seed oysters*.

Rearing and Greening. They are now removed from the tiles and are taken in hand by the "éleveurs," who rear and fatten them to a marketable size. This is done by arranging the *seed* on flat trays of galvanised wire netting, which are placed in shallow oyster "parcs" in which the tide circulates. Great care is taken with the rearing process, the oysters being constantly looked after by men and women who inspect the trays at low water and remove impurities and enemies, such as starfish. Thinning out is soon necessary, the growing oyster being removed to other trays or transferred to the floor of the "parc," which is often suitably prepared for their reception.

The process of *greening* is undertaken at Marennes, where the oysters are kept in muddy salt-ponds, in which they gradually become green, owing to the presence of a particular diatom in their food. At the same time they acquire a peculiar delicate flavour.

The Board of Trade Certificates for Fishermen. According to the provisions of the Merchant Shipping Act of 1894, no trawler of 25 tons tonnage or upwards shall go to sea from any port of England or Ireland unless there is on board a duly certificated skipper and a duly certificated mate or second hand.

Every fisherman with a spark of ambition will be interested to hear what kind of certificates are issued and what is the best way to set about obtaining one. The Board of Trade examines candidates for certificates of competency, and there are no less than ten different kinds of certificates to be obtained by any fisherman who is prepared to sacrifice a little of his leisure time. Five different certificates are issued to mates (second hands) and five to skippers.

A Mate's "Ticket." To obtain Certificate A, which is issued to *second hands* who fulfil the necessary conditions and pass the required examination, several preliminary qualifications are requisite. The candidate must not be less than nineteen years

of age, and he must have served at least four years at sea, of which two years must have been on board a deep-sea fishing boat. If he has served his time the candidate should apply to the nearest Mercantile Marine Office for a form of application, and he must take care to fill this form up properly. When the form is returned to the Office the candidate must attach to it his testimonials of general good character, and of sobriety, experience, ability, and good conduct on board ship. A fee of 1s. is charged for the examination. The candidate will be examined as to his vision, and, in addition, the rule of the road at sea, the marks on the lead-line and the use of the lead, taking bearings by compass, ability to use a chart, and generally as to the duties of a second hand. Questions regarding the rules of the road at sea are illustrated by means of models of vessels, and various coloured balls, representing lights, are used to represent vessels at night. Mates or second hands are also tested as to their abilities in reading, writing and arithmetic.

A Skipper's "Ticket." Candidates for certificates as *skippers* (Certificate B) must have served five years at sea, of which one year must have been as certificated second hand on board boats of 25 tons tonnage and upwards, engaged in the method of fishing for which the certificate is desired. An applicant for a certificate as skipper must be not less than twenty-one years of age. In addition to the subjects enumerated for second hands, skippers are required to be acquainted with general duties required for skippers, such as getting under way, what to do when engines are broken down, or when the vessel has sprung a leak, or when the rudder has gone, or on the use of a floating anchor. They are also required to make themselves acquainted with their civil duties under the Merchant Shipping Act of 1894; for instance, as to the returns of the list of crew, or as to agreements or apprentices' indentures. For extra certificates the applicant must show a knowledge of the use of the quadrant and be able to take observations, to read on and off the arc, to find the index error by the horizon, and to determine the latitude by the meridian altitude of the sun [see NAVIGATION].

Certificates for "Skippers of Steamers." Candidates for certificates as second hands and skippers of *steam* fishing vessels only have a somewhat similar examination to pass, but with the exception that they are not required to answer questions relating to such subjects as tacking and wearing, or rigging and masting of fishing vessels, or generally as to matters not required on steam vessels. Should the candidate not feel equal to any of the above tests, and be unable to pass the full examination, the examiners may, if they think fit, report that he has passed a limited examination, provided he has passed the sight tests and they are satisfied that he is competent to take charge of a fishing boat and that he is acquainted with the rule of the road at sea. Various County Councils have now instituted classes in subjects for certificates for management of fishing boats, and as a good deal of the instruction is of a practical nature, and cannot be learnt from a book, the candidate is advised to make local inquiries as to such classes.

Sea Fishery Law. The history of the legislation applied to the sea fisheries does not afford the student very pleasant reading. All the older legislative efforts of Parliament were based on a profound ignorance of the technique of the fisherman's craft. We are, however, not so much concerned with what the legislation has been as to what it is now, and along what lines its future development may be expected. The words of Professor Huxley (Inaugural address, Fisheries Exhibition, 1883) have lost none of their force at the present day, and as they embody the maxims or axioms which are fundamental they may well be reproduced here.

"Every legislative restriction means the creation of a new offence. In the case of fishery, it means that a simple man of the people, earning a scanty livelihood by hard toil, shall be liable to fine and imprisonment for doing that which he and his father before him have, up to that time, been free to do. If the general interest clearly requires that this burden should be put upon the fishermen—well and good. But if it does not—if, indeed, there is any doubt about the matter—I think that the man who made the unnecessary law deserves a heavier punishment than the man who breaks it."

The Necessity for Knowing Fishery Law. At the present day when considerable capital is devoted to the building and equipment of large and powerful vessels which fish to some extent near the territorial waters of foreign countries in addition to the waters of England, Scotland, and Ireland, the skipper of such a boat has to be acquainted with a not inconsiderable body of legislative enactments, which are here briefly summarised.

In the first place the whole of Part IV. of the Merchant Shipping Act of 1894 deals with fishing boats, but as the skipper of every English trawler over 25 tons tonnage undergoes an examination as to his knowledge of this section of the Act before he obtains his captain's certificate it will be unnecessary to do more than point out the main features of the Act. All fishing boats are (or should be) conspicuously numbered and lettered, and when fishing at night should carry certain lights, the details being given in the Act. Other regulations relate to the fishing boat's register, to discipline, to apprentices, and agreements with seamen. This Act, of course, applies to British fishing boats even outside British territorial waters. Other regulations for fishing may be divided into two groups:

(1) Those which are enforced on the high seas, or beyond the territorial limits.

(2) Those which are enforced only within British waters.

Regulations in Territorial Waters. There are three Acts which define the territorial waters within which His Majesty's subjects have the exclusive rights of fishing. The Convention Act of 1843 defines certain waters which are to be reserved for French and English fishermen in their respective countries, and here, in addition to three geographical miles from low-water mark (the distance allowed by international law), we find bays, the mouths of which do not exceed ten geographical miles in width, also reserved, and the limit is to be reckoned as being distant three miles to the seaward of a straight line drawn from low-water mark off one headland to low-water mark off the other headland of such bay respectively. By a subsequent Act of 1868, which, like the act of 1843, was intended to carry out a convention between England and France, we find a similar definition, except that the straight line across the bays is to be drawn from "headland to headland," no mention being made of low-water mark. This convention was never carried out by France, the necessary legislation to make it operative never having been passed. A later Act (of 1883)

defines exclusive rights of fishery as regards bays, and states that the distance of three miles shall be measured from a straight line drawn across the bay in the part nearest the entrance at the first point where the width does not exceed ten miles. This Act carries out a convention between England, Germany, Belgium, Denmark, and Holland. No definition of a "bay" is given, but presumably any indentation of the coast line is a "bay" within the meaning of the Act.

It must not be assumed that the exact delimitation of the territorial waters is a point of merely theoretical importance. Some of the laws restricting steam trawling in foreign territorial waters are very stringent. For instance, trawl fishing within the territorial waters of Iceland is punishable by a fine not exceeding 4,000 kroner (£220), together with forfeiture of all the fishing gear, including the drag ropes. That heavy fines are not infrequently inflicted English skippers know to their cost. Even to enter Icelandic waters with a trawl on board, not stowed away, is punishable by a fine of 2,000 kroner, and the ship, catch, and fishing gear may in either of these cases be seized and sold to cover the legal expenses.

Regulations for Home Waters Apart from the question of *territorial waters*, which are reserved to native fishermen, we have to deal with restrictions applied in the British Islands, and at the outset a fundamental difference is to be noted. For England and Wales, although the Board of Agriculture and Fisheries is the central authority for sea fisheries, the bylaws regulating the industry are formulated and administered by local Sea Fisheries Committees, which were called into existence by the Sea Fisheries Regulation Act, 1888. Although these bylaws are formulated by the committees they need the sanction of the central authority before they become operative. In Scotland and Ireland, on the other hand, the administration of bylaws is controlled by a central authority, and this distinction is accompanied by an extension of the area under control, for whereas in England and Wales bylaws only apply to the territorial waters, in both Scotland and Ireland the jurisdiction of the central authority extends beyond this. Naturally this extra-territorial authority can only be enforced against British subjects, at any rate, as long as their vessels fly the British flag, and already extensive evasions of the bylaws are practised by British owners who have placed their vessels under an alien flag.

In Scotland trawling is absolutely forbidden in territorial waters (the Herring Fishery [Scotland] Act, 1889); it is also forbidden in certain Scottish waters outside the three-mile limit, notably in Moray Firth and Firth of Clyde, and fish caught by trawlers flying a foreign flag in these waters must not be landed in Scotland, though they may be in England.

In Ireland no extensive advantage has been taken of Section 3 (1) of the Steam Trawling (Ireland) Act of 1889, which allows the Inspectors of Irish Fisheries to prohibit "beam-trawling or other trawling within three miles of low-water mark of any part of the coast of Ireland, *or within the waters of any other defined areas* specified in any such bylaws, and subject to any conditions or regulations contained in such bylaws." There are, however, certain extra-territorial waters closed under bylaws made in pursuance of this section, notably off the coast of Waterford.

Fishing Grounds at Home and Abroad. In England, trawling from steam vessels is practically prohibited within three miles from the shore; trawling from sailing vessels is only allowed with nets the meshes of which are a certain size, and there are in various localities regulations as to the tonnage of sailing trawlers. Certain grounds are closed to all kinds of fishing but lining. There is at present no regulation as to the size at which *sea fish* may be landed or exposed for sale, but such regulations are in force for shellfish.

Shellfish are frequently protected by closed seasons, and berried lobsters and crabs may not be removed from a fishery. Broadly speaking, the local fisheries committees absolutely prohibit wasteful and destructive methods of fishing. The powers of district committees are very extensive with regard to prevention of certain methods of fishing, or the regulation of fishing implements, but do not extend to imposing a size limit for sea fish. There can be little doubt that a measure prohibiting the landing of certain specified classes of sea fish under a certain size would be beneficial to the industry at large.

Steam trawler skippers who fish in the vicinity of foreign waters have to be careful. As a rule, the fines inflicted are excessive, being far above the modest £20 which is the maximum "penalty" in England and Wales; moreover, either to be in foreign waters with implements of fishing on board not stowed away or with the *intention* of fishing is in some cases punishable. That this regulation may at times be pushed to, or even beyond, its logical limits is evidenced by a recent decision of the German Appeal Court, at Leipsic, which decided in the case of the smack Lady Godiva that the presence of a foreign fishing boat in German waters with the *intention* of fishing was an offence equivalent to that of actual fishing.

Fisheries in the British Empire. Fisheries in the British Empire are in various stages of development. The Canadian fisheries both on the Atlantic and Pacific coasts are extremely well organised and are exploited to a high degree. The Canadian Government, unlike our own, is a disbeliever in the policy of *laissez faire*, and does everything in its power to encourage the fisherman. Not only are bounties paid to fishermen under certain conditions, but when points of special difficulty arise they are promptly dealt with. For instance, of late years the Canadian fishermen, like our own, have been troubled with a plague of dog-fish. The Home Government do nothing. The Canadian Government have erected several dog-fish reduction works where the fish may be taken by the fishermen and converted into commercial products of some economic value. Both in Australia and at the Cape the fisheries need exploiting, and probably the introducer of trawling on modern principles to either of these colonies will meet with a substantial reward. With regard to India, Major Maxwell, who represented the Indian Government at the International Fishery Congress at Vienna in 1905, said: "The fisheries of India are entirely undeveloped. Deep-sea fisheries as known in Europe are practically non-existent. The sea, however, contains incredible numbers of fish of all species. The population of India is over 300,000,000, and the great proportion would consume fish if they could get it. The riches to be gained by the exploitation of these fisheries would surpass the wildest dreams of avarice."

FISHERIES *concluded; followed by* FOOD PRESERVATION

TUBE MANUFACTURE

Cast-iron Pipes. Pipe Founding. Butt and Lap Welded Tubes. Seamless Tubes and their Manufacture by Various Processes

Group 14
METALS
11

Continued from page 5176

INTO how many articles of domestic, industrial, and public utility does tubing enter? We do not intend to supply the answer, for we cannot, but the question may cause the reader to look around him, and he will be surprised at the innumerable uses of tubing. The first use of metal tubing was for the manufacture of gun-barrels. The need for cheaper tubing than gun-barrels provided came with insistence during the early years of last century. The introduction of gas lighting called for very large quantities of tubing, and at first the need was met by old gun-barrels, of which there was a plethora after Napoleon had been finally housed in the island where he died. Then with the need for cheaper tubing came invention, and the files of the Patent Office contain the records of very many attempts to solve the problem of tube manufacture, each vieing with each in efforts after economy and quality in tube production. But we have to do with the practical, not with the historical, side of the question, and we may proceed to examine modern processes of tube manufacture.

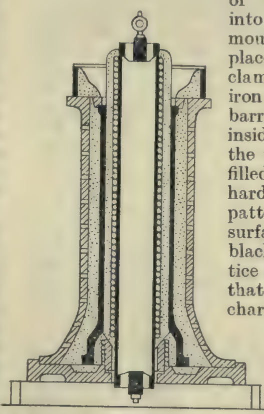
The word *tube*, or *tubing*, and the word *pipe* have the same meaning, and have been defined as "anything hollow or concave, and with some degree of length." The definition is comprehensive, and would include a nut or a washer. But length is the conspicuous feature of a tube, and anything so short as a nut or a washer would not come under the definition of a tube, although technically both of these articles are short tubes. The word "pipe" is usually applied to tubes of cast iron, and also to those of lead, but tubes of wrot iron or steel and of metals other than lead are usually designated by the word "tube." The difference is merely a matter of habit, and has become fixed. It is convenient, because to talk of an iron pipe is accepted as meaning something of cast iron, and an iron tube implies something of wrought iron.

Cast-iron Pipes. The chief use of cast-iron pipes is for water and gas mains. The usual length in sizes under 3 in. internal diameter is 6 ft., and for larger diameter pipes the length is usually 9 ft. American practice favours 12 ft. lengths for large water pipes, and there is economy in the longer length as there is then occasion for fewer joints.

Iron pipes are usually cast in a vertical position, and usually also with the socket end at the bottom. The practice is not universal, for small pipes are often cast in the reverse position, but the desirability for strength in the socket part constitutes a reason for it.

Cast-iron pipes are made by dry-sand moulding, which is the best and cheapest process where the metal is poured under any great head of pressure. This process of moulding does not demand so much skill as greensand or loam moulding, and consequently it produces cheaper work. Indeed, skilled labour is almost dispensed with in pipe founding. In the most improved practice the casting pits fill the purpose of core ovens as well. This utilises the heat left from the casting. When being used as ovens the pits are covered and flues admit the hot air.

The Moulding-box. The moulding-box [1] is made in two halves, and has a hinge joint, enabling it to be opened longitudinally. It is provided with perforations for the escape of gases as the metal is being poured, and also as the moulds are drying. The size of the moulding-box is sufficient to allow about 2 in. of sand between it and the pattern. Its base is made separate from the main shell, and before the moulding-box body is placed upon the base a cast-iron pattern of the socket is clamped into its place. Then the moulding-box or flask is placed upon its base and clamped thereto, the cast-iron pattern for the pipe-barrel is put into position inside it, the space between the pattern and the flask is filled with sand and rammed hard with long rods, and the pattern is withdrawn. The surface of the mould is now blackened. A common practice is to pour black-wash—that is, finely-powdered charcoal made with water into the consistency of cream—into it, care being taken that it gets around all the surface. The mould is then dried.



1. MOULD FOR CASTING PIPES

The moulding-boxes, after ramming, are placed over apertures, which are exhaust flues. The heated air entering the pit or oven—for in this capacity it is being used—passes up round the exteriors of the moulding-boxes and descends through the mould to the exhaust. After the moulds are dry the moulding-boxes or flasks are set in position for the pouring.

Preparing the Core. The core ought to be ready for insertion at this stage. Its preparation has been simple. Upon a long shaft, or arbor, is wound tightly a course of straw or hay rope of about ¾-in. diameter. This is done by placing the shaft or core bar upon trestles with grooves, in which the bar may rest, and by turning it with a handle fitted to its end. When one layer of rope has been put on, soft loam is applied and rubbed in between the spirals of rope throughout the whole length; then another course of rope is wound on, and more loam applied until the internal diameter of the pipe to be cast is reached. A loam board or *strickle-board*—that is, a templet the form of the edge of the longitudinal section of the desired core—is used to give it shape. The core may be partially dried during the process, otherwise the mass of loam and core rope would not be sufficiently cohesive to remain unbroken. It will also probably be bound with iron wire for the same reason. Then it has a last coating of sifted loam, sometimes mixed with sawdust, made thin with water, is "stricked," or made true to templet, and is finally dried. In pipe founding the core bar is

allowed to remain inside the core in the mould so as to give it strength, as a long core is necessarily weak. The core must have a diameter slightly larger than the internal diameter of the pipe desired, as the iron shrinks in cooling, the approximate shrinkage and the usual practical allowance being $\frac{1}{8}$ in. to every foot of diameter.

The cores made as described are treated to blackwash, as was the mould, and are then inserted within the mould.

The socket core is wrapped with hay rope and plastered with loam in the same way as the centre core, being also stricked by a templet and dried in the manner already described.

Collapsible iron bars have been tried instead of rope cores, as the latter are an expensive item in pipe founding, but they have not come into general use.

Casting a Pipe. The molten metal is usually poured from the top of the moulding-box, but sometimes large pipes have as much metal as will cover the socket-core poured from the bottom by a gate through the mould to the socket, the metal for the body of the pipe being poured from the top in the usual way. By this method there is less danger of injuring the socket-core by the heavy drop of metal upon it, but it gives the possibility of a "cold shut" between the metals of the two pourings.

Whenever the iron has set, the core bar is withdrawn by means of the crane, so as to prevent any danger of the pipe cracking as it cools, and the straw that is left at once begins to burn. When the pipe has dulled down to black, the shell of the moulding-box containing the pipe is hoisted up and placed over skids, where it is opened and the pipe rolled out upon the skids.

Flanged pipes are made in practically the same way, but it is a common practice to have a separate moulding-box for the lower flange and to clamp it on the cylindrical moulding-box used for the pipe body, the upper flange being made with a templet attached to a ring revolving on a pivot on the pattern, and a space being left for the cover.

Pipe Sizes and Weights. Cast-iron pipes are made from $\frac{3}{8}$-in. thick to $1\frac{1}{4}$-in. thick, and the following table gives the range of thicknesses in which the various sizes are made with the weight of each per lineal foot.

Dr. Angus Smith's solution is in very wide use for coating pipes that are to be laid underground. It gives the pipes a coating impenetrable to the liquid or other matters that usually pass through drain and water pipes, and it prevents corrosion. The original recipe took 60 gallons of coal tar, 60 lb. of freshly slaked lime, 12 lb. of tallow, 6 lb. of lampblack and 3 lb. of resin, all mixed together, boiled for half an hour, and applied hot. Present-day practice has departed from this, and there is not strict uniformity. A good method, largely followed, is to put coal-tar in a dipping tank large enough to accommodate the pipe to be treated, then to add one-seventh part by volume of pitch in powder form, and one-seventh part of coal oil. The pipes are heated to just under boiling point, say 200° F., and are placed into the mixture, turned over for a few minutes, and then withdrawn and allowed to drain.

WEIGHT OF CAST-IRON PIPES IN POUNDS PER FOOT

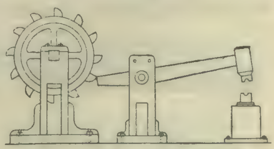
Bore in Inches	Thickness of Metal in Inches							
	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$
2	8·7	12·3						
3	12·4	17·1	22·2					
4	16·1	22·1	28·3					
5	19·8	26·9	34·4	42·3				
6	23·4	31·9	40·6	49·7				
7	27·1	36·8	46·7	56·8				
8	30·8	41·6	52·8	64·3				
9	34·4	46·0	58·9	71·7				
10		51·4	65·1	79·0	93·3			
11		56·4	71·0	86·4	102·0			
12			77·3	93·7	110·4	127·4		
14			89·6	108·4	127·5	147·0		
15				115·7	136·1	156·8	177·7	
16				123·1	144·7	166·6	188·7	
18				140·0	161·8	186·2	210·8	
20					178·9	205·8	232·9	260·3
22						225·4	254·9	285·0
24						245·0	277·0	309·4

Welded Tubes. Many improvements have been made in the processes of tube manufacture during the last fifty years. These have been chiefly in the making of seamless tubes. Welded tubes are made practically as they were made three-quarters of a century ago. There may be slight difference in the details of the process, but the principle has not been changed.

Welded tubes may be divided into two classes—*butt-welded* and *lap-welded*. In both cases a strip of flat metal is bent round into tubular form by special apparatus. Butt-welded tubes are those where the bending of the strip causes the two edges to *butt* or touch each other, and in this position they are welded. Lap-welded tubes, on the other hand, are bent round so that the two edges overlap, and in this position they are united by welding. A lap-welded tube must have a mandrel or solid rod inside when it is being welded, but a butt-welded tube can be welded without internal support during the process. Thus, very small tubes can be made butt-welded, but not lap-welded. Butt-welded tubes of iron are made as small as $\frac{1}{8}$ in. internal diameter, and they could be made even smaller, but the minimum internal diameter of lap-welded tubes is considered to be about 1 in. The manufacturer of welded tubing purchases "rolled strip" from the iron-rolling mills. This rolled strip is simply iron hoop or plate in the form of strips of the width necessary for the tubes about to be made. He converts this strip into "skelp," or tubes, the edges of which touch or overlap, but are not welded together. This is done by passing the strips through rolls, which first curve it and then bend it round until the edges touch or overlap.

Formerly, the tilt hammer process [2], patented eighty years ago by James Russell, of Wednesbury, was the common practice, and may still be followed to some extent. By this process the roughly-formed tube was heated to welding heat and passed along the grooved anvil of a tilt hammer, caused to strike rapid blows by the rotation of a wheel with projections as seen in the illustration. A mandrel was placed inside the tube being welded, if exactness in the internal diameter was desired, but if such exactness was immaterial, no mandrel was used. The invention of this process was an important stage in the development of tube manufacture, as it proved that a rough tube heated to welding temperature could be welded up merely by having its edges placed in contact and pressure applied, and without the need for the employment of an internal mandrel such as had been previously used.

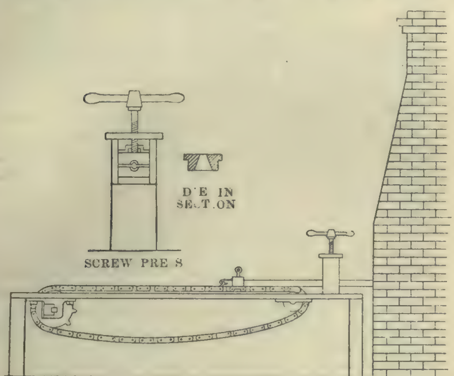
During the year after Russell began to exploit his patent, Whitehouse, of Wednesbury, introduced his draw-bench process, which is that still used, and which is best described in the words of the original specification (No. 5109, of 1825).



2. RUSSELL'S PROCESS FOR WELDING TUBES

"I prepare a piece of flat iron, commonly called plough-plate iron, of a suitable substance and width, according to the intended calibre of the tube. This piece of flat iron is prepared for welding by being bent up on the sides, or, as it is commonly termed, turned over, the edges meeting, or nearly so, and the piece assuming the form of a long, cylindrical tube. This tube is then put into a hollow fire, heated by a blast, and when the iron is upon the point of fusion, it is to be drawn out of the furnace by means of a chain attached to a draw-bench [3], and passed through a pair of dies of the size required, by which means the edges of the iron will become welded together."

He then describes the mechanism. The chain, which is driven forward by a spur wheel, carries a screw clamp in which the end of the metal strip is held. The iron tube, after having been heated almost to the point of fusion in the furnace, is led between the dies of the screw press and fixed in the screw clamp mentioned. Then the screw press is turned until the two halves of the die approach each other and make the desired opening through which the tube may pass; the gearing dragging forward, the chain is put into motion and the bent strip, entering the screw press dies, emerges from them in the form of a welded tube. It is withdrawn from the clamp and from the screw press. A small length of tube at the end where the chain clamp is attached is not welded. This piece is welded by returning that end to the furnace and, when it has been made white hot, by drawing it through the dies from the other end.



3. WELDING TUBES

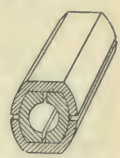
Sometimes the edges of the strips used for making butt-welded tubes are cut obliquely, making the weld thereby not a true butt, but a sort of lap. This practice makes a slightly better tube than the plain butt weld, but is still much inferior to the lap-welded tube, which we shall now consider.

Lap-welded Tubes. In its essentials the process of welding tubes with a lap weld is similar to that employed for butt-welded tubes except that a mandrel must be used to afford the necessary resistance during the operation of welding, as the pressure must be applied in a different direction to that when the weld is of the butt variety. Russell's original process (1845) which is that still usually practised, is described by its author as follows:

"The tubular skelp drawn from the furnace at a welding heat is placed upon a mandrel or what the inventor terms a 'beak iron,' which has a working surface of steel and is rigidly fixed at one end in a horizontal position, its free end projecting over a draw bench. The free end of this beak iron affords the necessary resistance and support when the lap joint of the tube, in order to weld it, is pressed upon by a roller while the tube is drawn off the beak iron by the action of the draw chain to which the grippers that have hold of the tube are attached. This system of working answers for tubes of large size, which are welded thereby at two operations, one half at a time. In making smaller tubes the mandrel or beak iron is required to be longer and of small diameter, and, consequently, as there is not sufficient substance to support the tube and its own weight horizontally without deflection, it is supported by a roller beneath the tube while the welding roller above is operating on the seam, the draw chain dragging the tube forward. The skelp in this case is drawn direct from the furnace on to the beak iron."

This process, that of rolling the skelp at welding heat and with a mandrel in the centre by one or more rollers, has been the subject of many improvements, but the only one that we shall notice separately is the Perrin process, which is, however, rather beyond the scope of an ordinary lap-welded tube.

The Perrin Process. The Perrin process of manufacturing tubes uses piled hollow blooms placed as in 4, and welded together by pressure. It is an important and a successful process, producing the apparently mechanical paradox of a seamless tube made by a welding process. The blooms are rolled into channel sections, and are placed as shown in the diagram. The edges must not butt where one channel section opposes a similar channel. This leaves room for compression, and a thorough weld between the external surfaces of the inner pair and the internal surfaces of the larger pair. When the piled blooms have been raised to a welding temperature the pressure of the uppermost outer bar upon the inner bars and the pressure of the inner bars upon the lower outer bar cause the parts to become united or partially welded along their adjoining circumferential surfaces, and by such welding before removal from the furnace the bars are retained in their proper relative positions during the subsequent rolling operation, which completes the welding. The piled bloom is rolled down at one heat sufficiently thin to form some sizes of gas, water, steam, or other tube.



4. PERRIN'S PROCESS OF TUBE MANUFACTURE

Spirally Welded Tubing. Spirally welded tubing is made and used to some extent. It is specially suitable for large tubes that have to stand high pressures. The spiral welds withstand bursting strains far above longitudinal welds. Another feature of merit is that this tube can be

made in very long lengths. Also spirally welded tubing that leaks at low pressures tends to become tight as the pressure increases, and to remain so. This property may seem curious, but it may be put to the proof. If we make a twisted paper tube, close one end, and blow into the other end of it gently, the air we send in escapes at the edges of the spirals, but if we blow into it with more vigour, the tube becomes tight. Thus, internal pressure on a spirally welded tube tends to force the overlapping edges of the spirals into closer contact, and to make the welded surfaces tighter, whereas internal pressure in a longitudinally welded tube tends to open the weld and to force the edges apart.

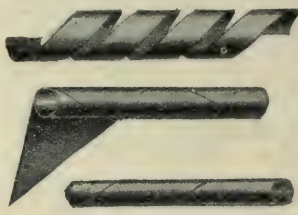
Making Spirally Welded Tubing. The process of manufacturing spirally welded tubing demands very accurate machinery. It is almost quite automatic, and does not entail highly skilled labour. The skill has been put into the machine. The "stock," or iron or steel plate, is rolled of the required width, and in as long strips as possible. The ends of these strips are welded together in a machine so as to give any desired length of strip in one piece. The completed strip or ribbon passes to the tube-making machine, which has four functions—feeding, bending, heating, and hammering. The end of the ribbon of metal is fixed to a guide table, set to the angle of the spiral, and is fed in by geared rollers. A mandrel is not employed but the mould is of a form to keep the size and alignment accurate. Projecting into the pipe, a distance a little in excess of the width of the skelp or stock used, is an anvil, cooled by water circulation and protected by firebrick. The furnace which raises the edges to welding heat is a small cast-iron box, lined with refractory material containing two nozzles, which are really blow-pipes, extruding a Bunsen flame upon the edges to be welded. One of these blow-pipes heats the edge of the pipe already formed, and the other heats the part of the skelp that is to be welded to it. The entering skelp meets the hot edge of the pipe just where the two flames from the blow-pipes meet; a hammer, with rapid blows, welds the two edges as they pass across the face of the anvil, the crimper also acting upon the work to preserve the proper curvature, and the pipe is made. The machine, acting as we have described, makes a foot of welded surface per minute.

Flanges of Spirally Welded Tubes. Spirally welded pipes are usually flanged, as this is the best way of joining them one to the other. The type of flange is what is known as the trumpet flange. The end of the pipe itself is turned over flat, thereby forming a narrow flange. The larger flange comes behind this, and has holes for bolts, so that two flanges are tightly pressed one against the other. But the strength of the union depends not at all upon the union of the large flange to the pipe, for the large flanges merely press the smaller flanges tightly together. Packing is, of course, used.

Spirally welded pipes have been made up to about 50 ft. long, but such lengths are convenient only when they are to be used close to the place of manufacture, because about 30 ft. is the longest that can be transported without the creation of exceptional facilities.

Spiral tubes, with the spirals united to each other by riveting instead of by welding, as described above, are also made to some extent, and their manufacture is cheaper than that of the spirally welded. Their chief economy is when they are of large size.

Helical Steel Tubing. Another form of spiral tubing is the so-called *helical tubing* [5] (Hillman's patent), used in the manufacture of Premier cycles. Long strips of sheet steel, usually of crucible cast-steel, is coiled round a mandrel, each spiral overlapping the preceding one to half of its width. The overlapping surfaces are then brazed together.



5. HELICAL TUBING

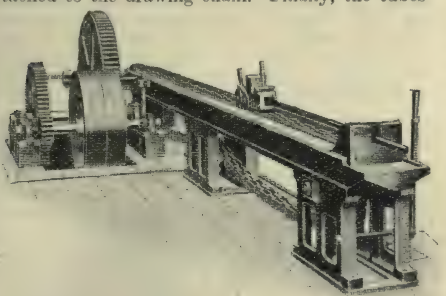
Seamless Tubing. Seamless steel tubing has many advantages over welded tubing, no matter what process of welding may be adopted. There are very many processes by which seamless steel tubing is manufactured. These processes follow one of three practices. First, there is the process of piercing the billet with a mandrel or drill, thereby making a short cylinder, to be afterwards rolled or drawn (or rolled and drawn) into the desired tube. Then there is the process whereby the billet is made with a core; and, finally, there is the wonderful Mannesmann process, whereby, under the action of rapidly revolving rollers of special construction, the solid billet is "spun" into tubular formation and attenuated to make the final tube. We shall look at these different processes in their order, selecting in the first two the main principles common to many adaptations of the process.

The manufacture of solid drawn tubes consists of two main operations — namely, rolling and drawing, the former being done while the metal is hot and the latter when it is cold. The material comes into the works in the form of billets, usually round, with a diameter of about 6 in. and a length depending upon the tube to be made, but usually from 18 in. to 24 in. The billets are, of course, solid, and the first process consists in drilling them with one hole up the centre longitudinally. Usually a special horizontal machine operating upon both ends of the billet simultaneously does this work. It is often done with the billet in a bath of water, which constitutes a lubricant for the drill and speeds up the work. The drilled billet is put into a furnace, and when it has been extracted hot, a hard steel mandrel is forced through the central hole to enlarge it. This is performed with the help of a hydraulic press.

Again the billet is heated, and the next process lengthens it, and it begins to assume a shape approximating to its final form. It is rolled between grooved rolls, while a mandrel is kept in position in the centre of the circular hole formed by the two grooves in opposing rollers. As the billet is passed through the rolls, it is forced on to this mandrel. It goes through this operation several times, each time having a smaller pair of grooves through which to pass. The mandrel over which it passes is shaped something like a bullrush, a head of the required thickness and a stem of thinner metal behind. Each pass of the tube through the grooves we have described forces it over the mandrel and on to the stem, whence it has to be removed to be passed through again until it is sufficiently drawn. With tubes of small diameter the bar or stem of the mandrel cannot be made sufficiently strong to withstand the resistance offered by the tube as it is being

forced on; so in this case the tube is first put on the mandrel stem and then drawn over the head through the grooved rollers. By this means the strain upon the mandrel stem is changed from one of compression to one of tension.

When the tube has been drawn hot in the manner described to a certain point, it is cut with a hot saw to length, and the finishing processes are performed cold. These finishing processes are: drawing through dies several times, and annealing and pickling between after pass. The machine used is the chain draw-bench [6], which we have already seen in use for making butt-welded tubes, but the test through which the tube passes is not a screw press, but a hardened steel die. Otherwise the operation is the same as we have already seen. The tube, as drawn cold, contains a mandrel, so as to preserve the true diameter, and each die being smaller than the external diameter of the tube as it enters, elongates the tube. The annealing furnaces must be large, as they have to accommodate tubes up to 25 ft. long. After annealing, the tubes are pickled in dilute sulphuric acid, to rid them of scale. Special hammers also are usually employed to reduce the ends of the tubes for gripping in the screw clamps attached to the drawing chain. Finally, the tubes



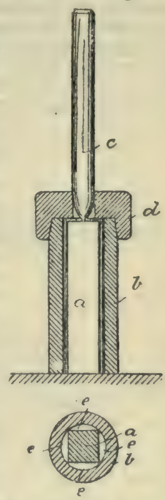
6. TUBE DRAW-BENCH

are cut by cold circular saws, and are ready for the market.

For very light gauges of tubing, such as used for cycles, the tubes are, after cold drawing, reduced further by a process of cold rolling. This operation is performed by means of two horizontal taper rolls placed side by side and tapering towards opposite directions. The tube, having inside it a mandrel fitting it exactly, is passed through these rolls, which stretch the metal, and can reduce a tube from 9 B.W.G. to 16 B.W.G.

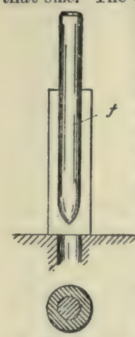
The Ehrhardt Process. In the process just described the billet is drilled when it is cold. It is also common practice to displace some of the metal from the centre of the billet when it is hot. One of the various methods may be adopted to this end. We shall describe briefly one such process. It is the Ehrhardt process, and is used in the manufacture of gun liners, shells and other war materials, as well as for making ordinary steel tubes. The process is as follows, in the words of the inventor's specification:

"To produce a hollow cylinder from wrought iron or steel, a piece of square iron or steel is taken, the cross-section of which, measured diagonally, corresponds to the diameter of the hollow cylinder to be pierced. The said piece of iron or steel [7*a*], when in a red-hot or white, glowing state, is delivered into the matrix *b*, the inner space of which also corresponds to the shape of the hollow cylinder to be produced, and a pointed core-bar, *c*, is then driven into the metal by means of a hammer or press, while the lid, *d*, is used as a guide for the said core-bar. The diameter of the latter is chosen so that the material forced aside by it is sufficient to fill the four segment-shaped spaces between the square sides of the block and the interior surface of the matrix. The core-bar enters the metal without any difficulty, as the metal, while being forced away, can give way at its sides, and a hollow cylinder with closed bottom is produced." The lower part of **7** shows a section of the square billet in the cylinder previous to the introduction of the core, and **8** shows the core, *f*, driven home, with a section showing how the billet is expanded to circular shape. The billet may be pierced from both ends as illustrated in **9**.

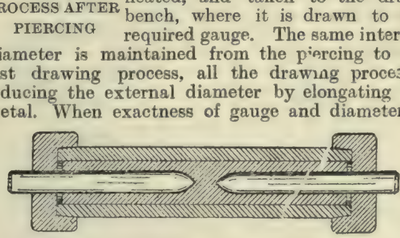


7. EHRHARDT PROCESS BEFORE PIERCING

This is the principle of the process, and we may make a brief examination of the practice. The billets used are generally of Swedish steel, and are received square, a shape which is an important essential. They are 10 ft. or 11 ft. long, and in section are from 3½ in. to 8 in. square. The billets are cut to lengths sufficient to allow sufficient metal for the pipe to be made. The cutting is done with cold saws when the sections are over 5½ in., and with hot saws when smaller than that size. The cut length at white heat is then put into a vertical hydraulic press provided with a circular die. The corners of the square billet just touch the internal circumference of the die, so that there are four segments between the die and the billet. A mandrel now descends and the billet is pierced, the metal displaced in making the hole causing the mass to expand and to fill the segments already mentioned. The mass of metal put into the die and the mandrel must be apportioned in size so that the metal displaced by the latter must exactly fill the cylindrical die at its circumference. The billet pierced in this manner is again heated, and taken to the draw-bench, where it is drawn to the required gauge. The same internal diameter is maintained from the piercing to the last drawing process, all the drawing processes reducing the external diameter by elongating the metal. When exactness of gauge and diameter is not of first importance, pipes may be finished hot. When these considerations are matters of moment



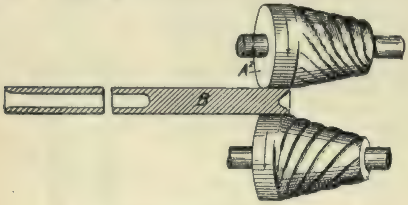
8. EHRHARDT PROCESS AFTER PIERCING



9. EHRHARDT PROCESS PIERCING FROM BOTH ENDS

the final processes are cold drawing, as described in the previous process, the tubes being pickled after the hot drawing and annealed and pickled after the cold drawing.

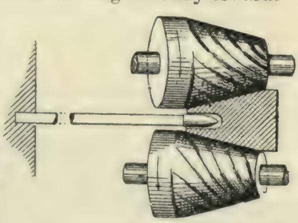
Tubes from Cored Billets. Several processes, by which the metal ingot from which a tube is made is produced with a longitudinal hole, thereby making it cylindrical in form, have been



10. MANNESMANN PROCESS

evolved and some are in operation. In one, the core is of oblong section and is, of course, made of some refractory material such as graphite. The billet, being cast with this core is flattened, making what is in effect a flattened tube. It is then opened and goes through several modifications of sectional form, ultimately becoming round and being drawn over mandrels in the usual way. Every process using billets already cored in their first state proceeds much after the same manner.

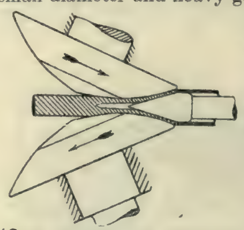
Mannesmann Tubes. The Mannesmann process of manufacturing tubes from steel ingots was described at its introduction in 1890 as "an epoch-making invention." The absolute novelty of the process and the marvellous results which it gave caused experts to be sanguine about the revolution it was to make in tube manufacture. To quote the words of one of the experts who hailed it with acclaim, it "accomplishes the apparent mechanical paradox of expanding a solid block of metal into a hollow steel tube with a void within several times its own original mass, by pressure applied from the outside, and this it does with great certainty, ease, and quickness." This is really what the process accomplishes. It must be stated, however, that the Mannesmann process has not killed every rival process, and to this extent it has disappointed the great expectations of its inventors and sponsors. It is one among many good processes, not the superlative process that has superseded all others. Its chief objection is that very great power is required for the machines necessary, and this means a high expense. Of the quality of the product there is no question. It was found that a red-hot billet led between two rapidly revolving rollers [10] of conical section or inclined longitudinally towards each other — revolving in the same direction— that is, with their opposing surfaces revolving in opposite directions, as indicated by the arrows in the illustration—was made to assume a hollow shape, of tubular form. What seems to be a vacuum is created. The space is, however, found to be filled with almost pure hydrogen gas given off by the hot iron. The heated billet is placed between



11. MANNESMANN PROCESS WITH MANDREL

the rolls, being led through guides, so as to make lateral motion of the rod or billet impossible. The end of the billet that enters the rolls is slightly flattened, and this causes the particles on and near the surface to be pushed forward more quickly than the remaining parts, thereby forming a cup-like recess in the end of the billet. As the rolls keep moving, the hot metal is pulled from the inside of the rod and pushed forward in the shape of a tube. Great rapidity is essential, or the metal would become too cool for manipulation before reaching the end of the billet. As already stated, the power required for this process is very high. It varies from 2,000-horse power to 10,000-horse power, according to the diameter of the tube in process of manufacture. The revolutions of the flywheels in the machines are so numerous that such wheels are usually made of large discs inside which and around the hub wire is tightly wound to give the necessary weight. Cast-iron flywheels would fly apart, and have, indeed, done so on several occasions before they were discarded.

A mandrel may be used when exactness of internal diameter is required [11] and when a tube of small diameter and heavy gauge is being made into one of larger diameter and thinner gauge. The Mannesmann process produces tubes of very high tensile strength. Figure 12 shows a different form of revolving cones.



12. MANNESMANN PROCESS

The Stiefel Process. The Stiefel process deserves mention as it has points of resemblance to the Mannesmann process. Two opposing discs mounted upon revolving vertical shafts parallel to each other and not in the same plane have faces with circumferential bevels. The hot billet is made to pass between these discs and on to a pointed mandrel placed in position, which pierces it in its progress. Suitable guide blocks are placed to keep the billet in its path.

Large Steel Tubes. Tubes of very large diameter have been made by a process of rolling subsequent to a rough drawing. The maximum size made hitherto by this process is 10 ft. long and 8 ft. in diameter, and there is no reason why the diameter at least could not be made much greater if it were desired. Such tubes have been used for rings for locomotive boilers, cylinder linings for hydraulic presses, and other purposes where high tensile strength is imperative, and where formerly the structures had to be made of plates curved and welded or riveted.

The process consists first in piercing a steel billet of suitable size into tubular form, and then of inserting a roller not shorter than the size of the tube desired, and rolling the tube already made, thereby increasing its diameter circumferentially as the shell is attenuated.

Die Press Process. Another process of tube manufacture consists in pressing discs of metal in a die press until after successive operations they evolve from flat shape to cup shape, then becoming longer, thinner, and of smaller bore under suitable pressing dies until they assume the ultimate form desired. This mode of manufacture is suitable for objects such as cartridge cases, and steel cylinders for gas, which in their final form are to have one end closed. They are thus cylinders rather than

tubes. The open end is, if necessary, narrowed or closed by compression, or, in the case of heavy iron or steel cylinders, the object may be made in two halves, which come together sectionally, and are united by welding.

Lock-joint Tubing. Various attempts have been made to manufacture lock-joint tubing, and the problems involved present no great difficulties. The usual practice is by rolling processes and through formers which bend around the edges of the strip into suitable shape, so that one edge may engage the other. Then the edges are brazed or soldered [see Soldering]. The manufacture of such tubing is limited, and is seldom used for making iron and steel tubing.

Taper Tubes. For some purposes taper tubes are desired. In the case of locomotive boiler tubes, for instance, they may be made parallel outside, but tapering inside, and therefore of heavier gauge at one end than at the other end. This is done in order that the thicker end may be placed where it is subject to greatest heat, and the thin end where the heat is less intense and the thickness superfluous. Brass and copper tubes are made with an internal taper by drawing them upon a taper mandrel the entire length of the tube, and by stripping them from this mandrel. Iron and steel tubes with internal taper are made by different processes. Ricketts' method provides that, in the process of drawing tubes through dies and over a bulb-headed mandrel, the mandrel should be made of slightly tapering form, and should have a very slow longitudinal travel, working automatically after the manner of the automatic feed on a drilling machine. Thus the space between the mandrel taper and the die, which space decides the gauge of the tube, is gradually widened, thereby producing a tube of gradually increasing gauge, and therefore with internal taper.

Heavy iron and steel tubes, such as are used as standards for electric lights and for electric railways are made by using as a die a pair of rollers provided with circumferential grooves with gradually increasing sweep. These rollers revolve in unison, and as they do so the die formed by the two grooves, while always remaining circular, increases in size, thus making the tube taper.

Annealing Tubes. In drawing tubes cold through dies as in wire drawing, the drawing process hardens nearly all metals, rendering them incapable or extremely difficult of further drawing and to reinvest them with the necessary ductility annealing is necessary. The annealing chambers, as we saw in considering wire drawing, are simply ovens of suitable size, and into these the articles are placed and maintained at a high temperature. Annealing, under the usual conditions, demands that the object annealed should be afterwards "pickled"—that is, immersed in a solution of hydrochloric acid (usually one part to 39 of water). This pickling removes the oxide of iron which the annealing has caused to appear on the surfaces of the tubes. Many attempts have been made to dispense with the necessity for pickling, and what is termed "bright annealing" is a not uncommon process. In bright annealing, the articles in the annealing ovens are annealed not surrounded by air as in the common process but by some gas which does not have the oxidising influence of the air. In some cases the annealing oven is put into communication with a coal gas supply service. By admitting the gas the air is expelled and the articles are then annealed without the formation of scale, maintaining their original brightness.

Other devices adopted include special methods of pickling. One process attempted removes the scale electrically by making the tubes anodes in an almost neutral bath, and by introducing lead or iron plates as cathodes.

Brass Tubes. The production of brass tubes is very large. Such tubes were formerly made by the primitive hand method, in which a strip of sheet metal was cut to the necessary width and bent around an iron rod. The edges of the partially-formed tube were then bound together with rings of wire, solder and borax were placed along the seam and fused in a common forge or under a blowpipe. Then, after being soldered, the tube was hammered round the rod upon which it had been formed, fullers being used in the process.

The present-day process of making tubes of brass and other metals gives results much better than the original method mentioned. Strips of metal of a suitable width are cut. In the case of large tubes demanding thick sheets the strips are put longitudinally through rolls—one concave and its fellow convex. By this device the strips are made into long channels the section of which is curved. Then, by beating it with a hammer, the end of the tube is tapered. The drawing tool is placed in position in the draw bench, and the tapered end, or tang, is passed through it. The draw tongs are made to grip the latter, and put into motion by means of the chain, which drags them along the bench, pulling the metal strip through the dies, and giving it the form of a tube with a seam up one side. Then the *wirer*—that is, a workman, or often a workwoman, responsible for the next operation—binds the edges together by encircling the tube with rings of iron wire at a distance of 2 in. apart. Then another operator, called the *charger*, places along the seam some *spelter*, or brass solder, in granulated form and mixed with borax.

The crude tube so prepared is now placed in a soldering stove, which must be of a suitable length. When it has been raised to a red heat, the brass solder and the borax fuse and unite the two sides, making the tube complete except for the finishing processes.

The binding wires are removed when the tube has cooled, and the surplus solder is removed by filing or grinding. Then pickling in weak acid cleans off the adhering dirt and the tube is again passed through a die on the draw bench. If a tube of absolute accuracy—internally, as well as externally—be demanded, a smooth mandrel is placed inside it before it receives this final drawing, and the drawing die, offering pressure to this resisting mandrel, makes a tube smooth in surface and uniform in gauge both internally and externally.

Solid Drawn Brass and Copper Tubes. The ingot which is to make brass or copper tubes must be carefully made, and certain precautions are necessary. It must be sound metal, and must have a sound face, or the chance of a good tube resulting is small. Clean metals poured into warm moulds should give the desired result. If the moulds are cold, and the cores warm, the latter will draw moisture, giving unsound ingots, in addition to which there is a danger of some of the metal blowing out of the mould. Usually, the casting is done in iron moulds set vertically and with warm cores. Mould and cores should be coated with plumbago or chalk, the former for preference.

Welsh coke is the best fuel, but if gas coke be used, it should be clean, or impurities may be carried into the metal.

With alloys of zinc, the heat should not be raised too high, or the composition of the alloy may be altered somewhat, and if exact specification be demanded, this may be bad. The flux used in making alloys must depend upon the constituents of the alloys, but it ought to produce a metal in a clean fluid state, and with melting temperature as low as possible.

A little lead, especially if it contain a percentage of silver, will make the process of rolling and drawing much more easy, and it is worth adding, but only a small quantity will enter into the alloy, any excess above this quantity squeezing out in cooling.

The hollow ingot, having been cast, is placed upon a mandrel and pulled through successive dies, each smaller than that preceding. Sometimes the mandrel is stationary as well as the die, and the tube is drawn between the two. Between each drawing the tubes are annealed and pickled, this being necessary to re-impart the ductility required.

Copper Tubes by Electric Deposition. Copper tubes are made by electrolytic deposition as well as by the mechanical process described. The chemical purity of electrolytic copper is well known, and when the plant is arranged to deposit the copper in the form of a tube there is a great saving of mechanical operations. Tubes made by this process are able to stand very severe tests. They may be doubled close cold and then doubled over ; they may be doubled close cold and then opened out, and they may be expanded and flanged with a flange three times the diameter of the tube—all without splitting or showing defects.

In the process of manufacture the copper is deposited upon a mandrel. For tubes up to 4-in. inside diameter the mandrel is of brass, and for larger sizes it is of cast iron, with a brass neck to take the current. The cast-iron mandrels, previous to use in the tube depositing tanks, are immersed in an alkaline electrolytic bath, containing sheet copper anodes, where they receive a thin covering of copper. The alkaline bath is kept at a slight heat. All the mandrels, whether of brass or of cast iron, are covered with plumbago, so that the finished tube may be easily removed after deposition.

The anodes used in the depositing bath are made from copper bars, which have been refined to remove arsenic and other impurities, and are practically pure copper. They are cleaned with diluted sulphuric acid before immersion in the depositing tanks. In operation the copper anodes and the mandrels are placed in the tank, the latter nested alongside of the anodes and resting on insulated supports at both ends. Acid sulphate enters the tank by gravitation from suitable reservoirs. The positive current reaches the copper anodes through lead conductors, and the negative current reaches the mandrels through copper conductors and flexible brushes. The mandrels revolve during the process, while agate burnishers travel along the whole length, giving to the tube uniform density and a surface of mirror smoothness. The coated mandrels after removal from the tank are treated in a tube expanding machine, and in a power draw-bench, which pulls the tube from its mandrel. Sometimes the tubes are subsequently drawn to different dimensions to those in which they leave their mandrels, and in this event they must be afterwards annealed and pickled.

Aluminium Bronze Tubes. Aluminium bronze is specially suitable as a material for tubes, for water-tube boilers, condensers, and acid industrial works. Its ability to resist corrosion is excelled only by gold and platinum, and its electric potential is almost nil. Aluminium bronze tubes are often drawn by the Mannesmann process, already described. To attempt to draw them on draw benches commonly used for drawing brass and copper tubes is to spoil the dies, which are not strong enough to resist the hardness and high tensile strength of the alloy. During the process of drawing, aluminium bronze tubes require frequent annealing.

Brass-cased Tubes. Much of what looks like brass tubing is only iron tubing covered with brass. Great economy is effected by substituting this so-called *brass-cased* tubing for solid brass tubing. Instances of its use are brass bedsteads and brass curtain poles. The latter are usually, however, of brass entirely when they are bent to fit oriel windows, The methods of making brass-cased tubing is ingenious and simple. The iron tubing is made from hoop or strip iron in the manner we have already described except that the butting edges are not usually brazed, welded, soldered, or otherwise joined. Then a tube of brass larger in its internal diameter than the external size of the iron tube is made in the same manner. The iron tube is put within the brass tube. It enters easily, being smaller. Then the two together are put on the draw bench and pulled through the die, which compresses the brass tube in diameter and extends it longitudinally. This mere pressing of the brass tube upon the iron tube gives sufficient adhesion for all purposes to which brass-cased tubing is usually put. Sometimes the brass tubing is brazed before being drawn down on the iron tube, but for some purposes this is not done. If we examine the brass-cased tube that serves for the head rail in a cheap iron bedstead, we shall probably find that the underside shows a seam. This is because, for considerations of price, the brass tube has not been brazed at its edges.

Tubes of Odd Section. Tubes of odd form, such as square, oval, D-shape, triangular, fluted, or polygonal, are made simply by making the drawing die and the mandrel the necessary shapes. They present no difficulties greater than those in drawing ordinary round tubing. When tubes other than round are desired to be made with their section spirally to the length, making thereby what are called *twisted tubes*, the tool through which they are drawn, in addition to being of the desired form, is made to revolve. It is geared to the wheels that operate the drawing mechanism, and thus a uniform number of twists can be given throughout the length of the tube. The tool in this case really acts like a screw-plate, putting a thread on the tube pulled through it. Many forms of ornamental tubing, such as are much used for gas pendants and other gas fittings, lamp standards, etc., are made by passing brass tubing through hard metal rollers containing grooves cut with the desired pattern. A solid brass tube is supported inside with a mandrel, so as to offer resistance to the pressure of the rollers, and by passing tube and mandrel through the machine the desired design is imparted to the tube.

Lead Pipe. Lead pipe, or pipe made of an alloy of which lead is the principal constituent, and termed *compo* pipe, is used largely in domestic plumbing work. The former practice of making lead pipes was to bend strips of lead round a mandrel and to solder the edges together. Such

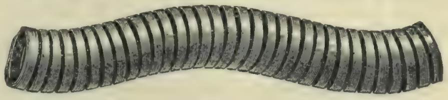
a practice has long been discarded, except where the small plumber makes his own traps, and pipes of lead are now forced by pressure through a hole or die the size of the external diameter of the pipe being made, and having in its centre a mandrel the size of the internal diameter of the pipe required. The power used is usually hydraulic, and the machine is a hydraulic press. The usual charge of lead is between 2 cwt. and 4 cwt., and this is poured in a molten state into the chamber. Pressure is applied before the lead has quite cooled, so that it is to some extent plastic. Sometimes a furnace surrounds the chamber, so as to keep the lead at its proper temperature as the pipe is being made. The smallest size of lead pipe—⅜ in.—is usually made in from 30 to 40 yard lengths, and large sizes —from 2½ to 6 in.—in 12-ft. lengths.

Extruded Tubes. An account of tube manufacture would be incomplete without notice of tubes produced by Dick's extrusion process, which is worked by the Delta Metal Company. It is really the process used in manufacturing lead pipe, by pressing it through a die applied to working alloys in a molten state. The machine which is called into use consists essentially of a cylinder and a hydraulic ram. The heated metal, usually an alloy of copper, is poured into the cylinder, at one end of which is the die. Upon the application of pressure from the opposite end, the plastic metal issues through the die as a rod or tube, conforming in section to the shape of the die. The chief use of this process is in making bars or rods of odd sections, which could not be rolled; but many articles of tubular formation are also made. In their case, a mandrel is placed within the die, and this gives the form to the internal diameter of the article to be extruded. Successful operation of this process is due to the fact that the alloys that are treated may be separated into more than one stream when in a plastic condition, and will reunite readily and perfectly under simple pressure if no air has been admitted to oxidise the fresh surfaces created. This separation takes place in the cylinder, because the metal is broken into two or more streams as it passes the arch that holds the mandrel in position; but a reunion takes place before the metal comes to the die. Alloys of copper are usually extruded at the temperature of plasticity, which is about 1,000° F. For small work, the cylinders are fitted with several dies—up to four in number—and four tubes or rods are produced simultaneously.

Flexible Metallic Tubing. The desirability of having flexible tubing much stronger and more durable than is possible with indiarubber admitted flexible metallic tubing into immediate favour, and new spheres of usefulness are continually being found for it. It is made by the United Flexible Metallic Tubing Company, Limited. It is largely used in railway work for water-fed pumps from the engine to the tender and for heating carriages. In countries of extreme temperatures, that cause rubber to perish within a short time, flexible metallic tubing is extremely valuable. Rock drills actuated by compressed air often have the air supplied to them through this variety of tubing with excellent results. It has also been used to pump liquid fuel in the form of petroleum from one vessel at sea to another while both were going ahead at almost full speed, thereby saving a good deal of time in ocean voyages. These are merely a few of the many uses to which flexible metallic tubing is now put.

The process of manufacturing flexible metallic tubing demands great care, and the resulting tubing must fulfil two conditions—it must be flexible and it must be water and air tight, even, in some cases, under high steam pressure. It would be easy to make it flexible at the expense of the latter quality, and it would be easy to make it airtight at the expense of flexibility. To serve its purposes, however, it must have as much flexibility as is consistent with absolute airtight qualities.

Making Flexible Metallic Tubing. The first thing necessary in manufacturing the tubing shown in **13** is an extremely tough, and, at the the same time, highly ductile metal strip or ribbon



13 FLEXIBLE METALLIC TUBING

of absolutely uniform width and of very great length. This ribbon—of steel, brass, copper, zinc, or, indeed, any metal sufficiently ductile—is drawn through successive formers, which gradually shape it from the flat strip into a sort of double tube having the section of the figure 8, only the ends turned over do not butt close up to the central web. The final process is that of coiling this strip in a spiral form round a core, causing the lower part of each spiral to engage the upper part of the spiral to which it is united, thus forming the tube. In this operation the tension of the strip, the accurate adjustment of the metal surfaces, and the mode of release from the core or mandrel upon which the tubing is made, are the matters of chief moment. All these operations are accomplished in a single machine, which receives the plain metal strip and delivers the tubing complete and ready for use. Very long tubes can be made by the process described, the length being limited only by the limitations of the strip that can be supplied to the machine. Thus, to make a tube ¾ in. in diameter requires strip $\frac{6}{10}$th millimetre thick and 14 millimetres in width, and the limits of length for metal strips of this section is from 6,000 ft. to 7,000 ft. It requires 10 ft. of strip to produce 1 ft. of tube, and this gives 600 ft. to 700 ft. lengths of tubing of the size mentioned. When tubing is required in greater length than this, these long strips are united by electric welding, so that there is no practical limit to the length that may be supplied in one piece.

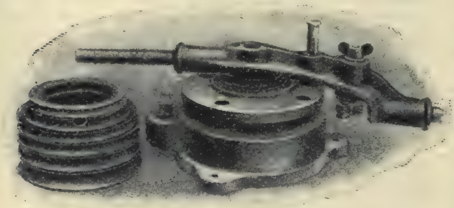
For steam purposes, flexible metallic tubing is made of copper, pure or alloyed; for use in pumping oil, and other purposes, steel is used; brass tubing is provided for locomotive work, and for use as gas tubing in making flexible connections, both steel and zinc are employed. For suction as well as for use under compression, this tubing is excellent.

Gas Fittings. An important use to which tubing is put is the manufacture of gas fittings. Into the many forms of gas fittings space will not permit us to enter. We can record only the present tendency of the trade. Undoubtedly the invention of Auer von Welsbach—the incandescent gas mantle (see GAS)—gave to gas lighting a hold which it was gradually relaxing, and postponed the general adoption of electricity as a domestic illuminant. The tendency of taste in modern gas fittings is away from the sliding water-sealed chain and weight gaselier towards fixed pendants and brackets, and to pendants that can be raised and lowered without a water-sealed tube. The popularity of the inverted gas mantle is creating

a demand for new styles and new designs in gas fittings, and at present there is no evidence that fixity of design has been attained or that the problems of construction have been properly solved.

In gas fittings, soft or tinman's solder is avoided, and hard soldering or brazing is adopted. Ornamental tubing such as we have already noted is used extensively for gas fittings, but even here there is a distinct tendency towards plain, round tubing, and to lightness and grace contrasted with ornament and elaboration. Mountings of gas fittings are to a great extent stamped brass work. Taps, swivels, and couplings are, of course, cast brass, and are made chiefly by semi-automatic machines. Ingenuity is being exercised in the finishing of gas fittings, and fashion, to some extent, holds sway here.

Tube Bending. Cast-iron pipes, of course, cannot be bent at all. Wrought iron and steel tubes are often filled with sand, heated to redness, and bent round a shape, the welded side being kept at the inside of the bend. Brass tubes for curtain-



14. KENNEDY'S TUBE-BENDING MACHINE

poles and other purposes are filled with pitch, and, when cold, bent round something of a suitable shape. Then the tube is heated, and the pitch remelted and poured out. This demands that the tube must be repolished. A coil-spring mandrel is also used for bending tubes for cycle and other work. The mandrel is screwed up to its minimum diameter and inserted into the tube. Then, by turning a key at its extremity, it is distended inside the tube as far as the internal diameter of the latter will permit, and the bend is made, the mandrel resisting the flattening at the bend which would otherwise take place. The mandrel is again screwed up tightly and withdrawn. This method cannot give very sharp bends, and the spring mandrels are expensive and somewhat brittle.

Some machines have recently been invented for the purpose of bending tubes, and perhaps the best is Kennedy's patent [14], which is now used by several Government departments. It consists essentially of a circular plate grooved on its periphery to suit the tube to be bent. A plate of the proper size is placed on a vertical centre, and a hard steel grooved block, mounted upon a lever and made to describe an arc parallel to the periphery of the plate, is pressed against the outer side of the tube, thus making the bends. By a sufficient number of grooved discs, and a machine of the proper capacity, this machine gives a very wide range of bends that may be made and sizes of tubes that may be handled. The weld—if the tube be of the welded variety—should be on the inside of the bend. In the largest size, the power is applied manually by a worm and wheel arrangement.

Measurement of Tubes. The measurement of brass and copper tubes is calculated upon the outside diameter, and tubes of iron, steel, lead, and composition, or *compo* tubes or pipes, by the inside diameter. The reason for the apparent anomaly is that brass and copper tubes are used largely for purposes where the external size is the important consideration, and that the chief purpose of the tubes of other metal is to pass water, gas, or steam where the quantity that the pipe or tube will take is the important point. The result of this method of calculating size is that tubes—say, ½ in. diameter—for gas, water, and steam respectively—look very different from each other in external diameter.

It is the practice of most tube-makers to manufacture welded tubes for water one gauge thicker than gas tubes, and steam tubes again are one gauge thicker than water tubes. The usual gauges, thicknesses, and weights of the three varieties of tubes and the number of threads per inch in the screws used for them are given in the table that follows:

WROUGHT-IRON TUBES FOR GAS, WATER AND STEAM

Bore in Inches.	Screw Threads per Inch.	GAS			WATER			STEAM		
		S.W.G.	Thickness in Inches.	Pounds Weight per foot.	S.W.G.	Thickness in Inches.	Pounds Weight per foot.	S.W.G.	Thickness in Inches.	Pounds Weight per foot.
¼	19	14	·080	·330	13	·092	·419	12	·104	·448
⅜	19	13	·092	·530	12	·104	·627	11	·116	·694
½	14	12	·104	·840	11	·116	·924	10	·128	1·008
¾	14	11	·116	1·176	10	·128	1·288	9	·144	1·400
1	11	10	·128	1·680	9	·144	1·848	8	·160	2·016
1¼	11	9	·144	2·464	8	·160	2·632	7	·176	2·800
1½	11	8	·160	3·136	7	·176	3·472	6	·192	3·808
1¾	11	8	·160	3·463	7	·176	3·804	6	·192	4·145
2	11	8	·160	3·791	7	·176	4·137	6	·192	4·482
2½	11	7	·176	5·334	6	·192	5·846	5	·212	6·350
3	11	7	·176	6·350	6	·192	6·936	5	·212	7·563
3½	11	7	·176	7·303	6	·192	8·020	5	·212	8·732
4	11	7	·176	8·047	6	·192	8·767	5	·212	9·488

Continued

HOW TO LINE HAT BRIMS

Preparation of Hat Brims for Fancy Linings. Velvet Binds and Crossway Folds. Preparing and Joining the Material. Making and Sewing in Bandeaux

MILLINERY
continued from page 5219

By ANTOINETTE MEELBOOM

DIFFERENT kinds of binds may be used to make brims more becoming to the face of the wearer, and also to form part of the trimming of the hat. Before a rouleau, velvet bind, or French fold can be sewn to the hat, the brim must be prepared.

Remove the wire already on the hat, as it is generally too thick and will cause the rouleau to stand out from the brim too much; and, secondly, it is very often of inferior quality, and is sewn on with stitches so far apart that it does not answer the purpose for which it is required—that is, to keep the brim in shape. A strong fine silk support wire to match the straw or felt is substituted, and, in the case of a straw hat, is sewn on the width of one straw in from the edge.

With open fancy straw it must be sewn on the part sufficiently strong to hold the stitches. Use wire stitch, and allow 2 in. on the wire to cross at the back [106]. The stitches must exactly fit the wire, and not be too far apart, or the wire will not set well round the curves. Contract the wire slightly for a turned-up brim.

Pin on the rouleau with lillikins, or steel pins, over the wire [105], stretch it slightly, cut away what is not wanted, allowing ½ in. for turnings for the join. Undo the fold for a few inches on either side, and join on the cross [114].

If there is already a join in the rouleau, see that the joins slant in the same direction, and herringbone the edges together again. Pin in place and slipstitch it to the hat just above the wire all round. The rouleau should lie quite flat, and no stitches must show on the right side. Felt hats are prepared in the same way, except that in smooth felts the stitches must not be taken through the brim, but only through half the thickness of the felt. Use a very fine needle and cotton. Felt hats are often wired at the edge, mulled, and trimmed with a velvet, silk, or braid bind.

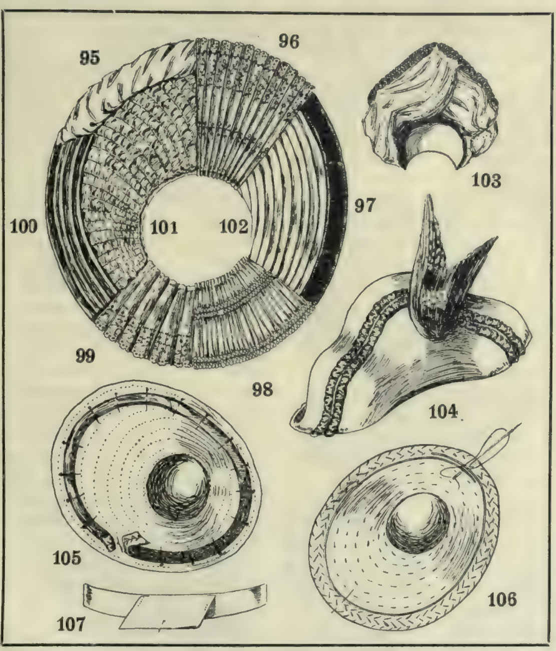
Velvet Binds. For a velvet bind [97], measure round the edge of the brim. Most brims require one and a half to nearly two crossway lengths of velvet about 3 in. wide. Shade and join the velvet. Pin it on the hat and join in a round. Press the seams. The joins are very difficult to manipulate and show the difference between amateur and professional workmanship.

Stitch it in on the outside of the hat with long backstitch, the right side of velvet to upper side of brim. Turn over carefully and turn in the raw edge with the needle—on no account use the fingers, which would stretch the edge of the velvet. In boat-shape, French sailor, or similar turned-up brims, the bind, if carefully put on, will keep in place on the outside without any other stitching. For curved or fluted brims, the bind must be slipstitched on the underside, in order to set it in the curves. A corded or plain ribbon bind to a felt hat is evenly stitched with twist, the same size stitch showing on both sides of the brim.

Another effective way of trimming the edge of the upper and under brims is by narrow crossway folds in velvet or silk [100], the fold of each row overlapping the raw edges of the previous one, the last being finished with a rouleau or French fold.

For a wide velvet or silk bind of 1 in. or more wide, on either side of the brim, measure round the edge, join the material in a circle, and press the seams.

Fold the velvet in the centre, stretch the centre of the fold with the blunt end of the scissors; be very careful only to stretch the *centre*—not the cut edges. Place this on the



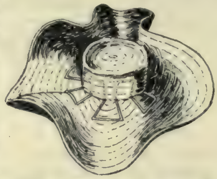
95–107. HAT-BRIM LININGS

edge of hat, turn in the raw edges, and slipstitch top and bottom, being careful not to draw the velvet.

Full gathered or rucked edges on hat brims in either velvet or silk are made of crossway pieces, in length twice and a half times the circumference of hat, and about 3 in. wide. Join them in a circle, mark the half and quarters also on the hat brim. Regulate the fulness evenly, and secure the material by the long backstitch to the brim, along the gathering thread. Turn over the velvet and slipstitch down to underside of brim.

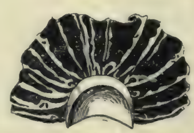
A much softer effect is obtained by not pulling the fulness tightly over the edge ; also by regulating the fulness *diagonally* over the edge before slipstitching it to the under brim [**95**].

A cord run in a velvet tuck at the edge of velvet, drawn up to size of edge of hat, sewn on, the underside turned in and slipstitched as explained before, is another pretty finish [**104**].



108. WIRING "FLOP" BRIMS

Satin wires used on felt, velvet, or straw hats are slipstitched to hat brim, the stitches taken through the underside of silk filament of the wire, to prevent them showing when the hat is worn, and through half the thickness of brim in felt.



109. VELVET BONNET LINING

For joining at the back, side, or wherever the trimming is likely to come, carefully undo the silk filament at each end ; cut away some of the cotton covering which is underneath, overlap the two wires for 2 in., twist the cotton covering round them, and wind round the silk filament again very gently. If carefully done, the join will be invisible. If two wires are to be placed very close to one another, there is no need to finish each round ; the first one may be taken on to the next.

Crossway folds of silk or chiffon [**102**] for hat brims are cut 2 in. wide and joined in one length. Tack the edges together. Straw, felt, and velvet brims must first have a facing of mull, leno, or silk. Start from the outside edge, avoiding any joins showing in front of brim. Arrange each fold separately, *slightly* stretching the outside edge. Stitch each row in position, hiding the stitches of the previous ones.

Chiffon Linings. Gauged chiffon linings [**98**] take from three to four and a half times the circumference of brim ; of fine tulle even six times, and the depth, plus as many tucks as required, is not too much to obtain a good effect.

Mark the half and quarter of the length, run three or more tucks at the edge ; pin, and sew on hat just above the wire. Make more tucks, regulating the distance according to the shape of hat brim. Pleat evenly in the headlines.

Plain tucked chiffon linings are made with the tucks about $\frac{1}{8}$ in. to $\frac{1}{4}$ in. wide, each just overlapping the other. The tucks are usually run selvedge way, but they may be made on the cross. Slipstitch round the edge of brim and gather the fulness in the headline. Chiffon or silk may be gauged diagonally [**101**]. Draw up the gathering threads. Ease on round edge of brim. Cut the silk on the cross one and three-quarters the depth of brim, and one and a half times the circumference.

Pleated lace linings [**96**] have a tiny stitch taken *on* each pleat.

Fluted lace linings [**99**] have a tiny stitch between each pleat, and the lace is pleated evenly in the headline.

Beads are sometimes used as trimmings. They are threaded on fine wire and sewn on with a stitch taken through the bead into the shape. The wire should be held firmly with the left hand.

Soft felt, straw flop, or capeline hats [**108**] are wired round the edge. These shapes also need four extra wires to give support to the brim and crown. The wire is run for about $1\frac{1}{2}$ in. to 2 in. in crown. These are also wired round headline, or a band of net or buckram wired top and bottom may be used. For deep crowns, a separate wire foundation must be made.

The wiring of brim is done either underneath or on the top, according to whether the brim is to be turned up from the face or not. If wired on the outside, the trimming will in most cases cover it.

Bonnet Shapes. Nearly all bonnets have full or rucked edges which make a becoming front trimming for the face. There are two kinds, either for the open front or the close-fitting bonnet.

For the open front [**109**] a full velvet lining is often necessary to fill up the space between the bonnet front and the head.

For the close shape [**103**] a rucked edge is used to take away the hardness of the shape.

For the open front, measure the depth of the centre-brim and allow half as much again for fulness. Measure the outside edge of brim and allow half to three-quarters as much again for fulness.

If one length of velvet is insufficient, add on narrow pieces each side, as a bonnet brim is always much narrower near the ears. If a longer piece is necessary, join the piece on either side and cut afterwards in the middle of the narrow part [**107**]. Mark centre-front and gather each edge. Prepare the bonnet edge in the same way as the hat brim is prepared for a fold.

Place centre of velvet lining to centre of brim. Arrange most of the fulness in centre-front, lessening it gradually towards the ears. Backstitch the velvet on closely, just above the edge wire on the line of running stitches. The lower edge is stitched round the head and the velvet arranged in light puffs with the point of the needle.

For a "rucked edge," the measuring, cutting off, and preparation of velvet are the same as just explained, the only difference being that the velvet is not usually stitched on the edge of the bonnet, but about 1 in. to 2 in. *above* it.

The needle should never be put through the double pleat of the velvet; it should be brought back close to where it went in and the cotton tied. Lightness of touch, to use no more stitches than necessary, and never to draw the fulness tightly over the edge, are points to be remembered. The bonnet should next be headlined.

Preparing the Velvet. Velvet is a rich-looking fabric whose chief characteristic is its *pile*, or raised surface. It has a short surface which, in coming from the loom, is pressed slightly in one direction, thus casting a shade, and giving it a darker tone against the pile than with it. Experienced fingers can feel the way the pile lies, it being smoother in one direction than the other. The better the quality of the velvet, the more distinct is the shade. In correct shading lies much of the difference between amateur and professional work. Hold the velvet to the light, and, before joining or cutting out, see that the pieces shade the same way.

Three kinds of velvet are in general use—the silk, the patent, and the cotton back. Velveteen is too heavy, and is used only occasionally to match children's Liberty coats and pelisses. The silk-back velvet is manufactured entirely of silk filaments; it is very light, has a close pile, keeps its colour to the last, renovates well, and is always used for the best class of work. Its price is from 7s. 11d. a yard. It wants careful manipulation, as the lightness of its pile causes it to be easily plushed or flattened.

The "patent-back" velvet is a mixture of cotton and silk, but it is easily distinguished by its highly-glazed back. In the best qualities it can be mistaken for silk velvet. Its price is from 3s. 11d. upwards. It is much in use and can be obtained in a wide range of colours.

In cotton-back velvet, as its name implies, the pile alone is of silk. It is of much more open texture, soon fades, and is heavier to wear. It is only used for very cheap millinery, and costs from 1s. 11d. Miroir velvet, of the same quality, has a much better appearance because the pile is flattened down uniformly and prevents the foundation showing through the pile.

Several other kinds of velvets are used, such as panne, chiffon velours, terry, caracul, shot, plissé, corduroy; but these are only passing fashions, and their use for trimmings or coverings at once dates a hat or bonnet.

If required for trimmings only, buy the velvet on the *cross*. For covering hats it should be bought on the straight. A *corner of velvet* is extremely useful for toques or bonnets.

If we have a length of velvet on the straight, before we can cut crossway widths for trimmings, a corner must be cut off. Place the velvet on the table with its pile uppermost, and the fold *from you*—this is important. Fold the two faces of the pile together when they will not want pinning. Take the right-hand lower corner, A, of the cut edges to the selvedge of the opposite side, B. The two selvedges must be exactly at right angles. Then cut through this fold. Any length corner can be obtained by folding the velvet as from C to D instead of from A to B [110]. The extra length obtained along the top is short at lower edge [111].

A corner of velvet, it will be seen, is a shaped piece with one side on the straight and one on the cross. In covering and trimming bonnets and toques pieces can be cut from the crossway side for the trimmings, while the corner and straight part are used for covering or draping the bonnet or crown.

To cut a crossway width [112], measure the length required first along one selvedge and then along the other; snip the velvet at those points; fold it over—from you—and cut off. Be very careful that the velvet is really cut on a true cross; if there is the least inaccuracy the folds, rouleau, or trimming will not lie well and the material will be wasted.

A crossway length will measure one-third less *through the centre* than along the selvedge, and allowance must be made for this when estimating quantity required. By "through" is meant through the cross—as opposed to along the selvedge. This should be noted as the word will be so employed throughout this course.

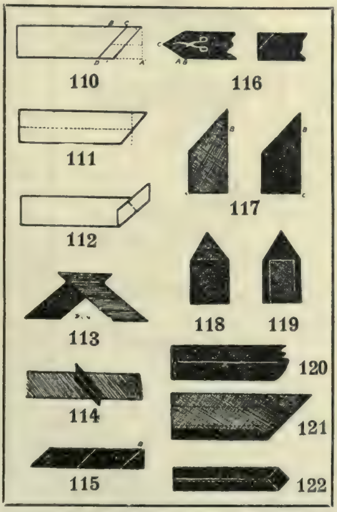
Joining Velvet. To join velvet [113] shade the velvet correctly, place the two piles together, leaving a little triangle at each edge [114]. Backstitch them with fine cotton and needle—the stitches must be quite close and tight so that there may be no gaping when stretched.

To straighten two crossway lengths for trimming, shade the pieces and join. Cut off a corner [115] and join it to A B.

To straighten one crossway end, fold A to B, stitch it and cut [116].

Trimmings and bows are frequently made of crossway widths of piece velvet. After joining the length, the raw edges must be hemmed, which can be done either by turning in the edge once, as for twists, knots, etc., or turning in the edges twice for the loops and bows, and making a narrow roll hem. In the latter case a fine wire may be inserted in the hem.

Ends of crossway pieces can be used up in making ends and ears. Ends, if faced with velvet, must be stitched along



110–122. PREPARATION OF VELVET FOR TRIMMINGS

the straight side and slipstitched along the crossway side. They do not set well if not treated in this way. Pull out the point from the outside with a fine needle. In stitching do not pull the cotton tightly. Stitch as from A to B [**117**]; slipstitch from B to C. Always stitch for 1 in. round the point at B.

An ear is made by the long point being turned back pile to pile and stitched [**118**]. Turn out and hem along bottom edge. For unlined ends and ears the edges must first be roll hemmed [**119**]. Ends and ears may be lined with a contrasting colour of velvet or silk, joined in the same manner as described above. How to wire ends and ears is dealt with later.

For a velvet fold or rouleau, cut crossways a piece twice as wide as required, turn down each side, so that the cut edges just meet in the centre, and lace-stitch the two edges together. Another method is to slightly overlap the edges and hem as for velvet. Do not cut the rouleau too wide or it will not set well.

For a French fold [**120**], cut material three times the width of the required fold. Fold it in three, one cut edge inside and one outside. Turn down the outside edge and slipstitch it, begin careful the fold does not become twisted.

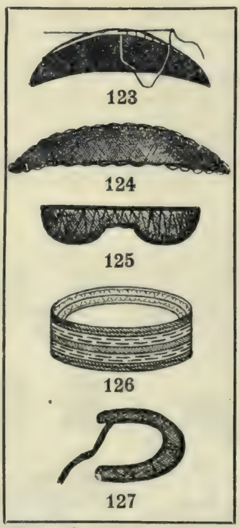
Velvet Bonnet Strings. Ladies sometimes prefer piece velvet bonnet strings to ribbon, because it may be impossible to obtain ribbon velvet to match, and they are warmer to wear, and more becoming.

Cut three times the width required when finished. Usually two widths 2 in. "through" are needed. Shade the pieces and join. Make a cravat end [**121**], and slipstitch as for French fold. Place the fold exactly opposite to the point of the cravat end. The strings should be about $\frac{5}{8}$ in. wide when finished.

Another way is to hem a long piece of cross-cut velvet, make the ends up in bows, and tie under the chin. The width is a little narrower than the $\frac{7}{8}$ in. ribbon velvet usually sold for bonnet strings because it is thicker. Piece velvet bows are made of velvet cut on the cross. The widths should be joined in one long length, and the edges roll hemmed.

Bandeaux. The style and fit of a hat depend frequently on the right shape of the bandeau, which gives it the proper tilt on the head. When it is made, pin it in, trying different positions till the right one is obtained. Often a hat does not suit because it needs a bandeau, or because the bandeau is in the wrong place.

Bandeaux vary in size and shape, and are usually covered with velvet, which clings to the hair and helps to fit the hat. They are used for these purposes: To tilt a hat at front, side or back; for sewing trimmings underneath; or to make a faulty headline either larger or smaller.



123–127. HAT BANDEAUX

In form they are either *shaped*, *round*, or *straight*. Shaped bandeaux for front, side, or back, are made of spatrie or buckram; for light hats, such as chiffon, lace, tulle, of double stiff net. Round and straight bandeaux are made of stiff net and ribbon wire.

First cut out the shape in buckram and wire it with firm support wire [**124**]. Start wiring in the centre of the straight side of the bandeau and allow 2 in. for overlapping.

Mull the edge. Cover it with a crossway piece of velvet, placing the straight side of bandeau to crossway part of velvet [**123**]. Pin it in place. Cut to shape, leaving $\frac{1}{2}$ in. turnings round curved part. Turn in and slipstitch, cutting the bandeau in shape as it is worked.

Bandeaux for back of hat [**125**] must be covered in two parts. Cut the velvet to shape, leaving $\frac{1}{2}$-in. turnings. Tack one piece, turning the edge over all round, and catch-stitch it to the spatrie. Pin on the other piece of velvet, turn in the edge, and slip-stitch all round.

Net bandeaux for light lace, net, chiffon, etc., hats are made of double stiff net, wired all round, with support wires inserted between the two thicknesses of net, and nipped securely over the edge. These are covered with one or two thicknesses of tulle or chiffon, and bound with sarcenet or narrow velvet ribbon [**127**].

Shaped, all-round bandeaux are made of support wire to given measurements in the same way as wire shapes are made. These may be covered with straw or velvet, and, for a very deep shape, only the outer side need be covered.

Round bandeaux [**126**], used for reducing size of headline, should be made in this way: cut four thicknesses of stiff net, about 1 in. wide, and in length $\frac{1}{2}$ in. smaller than headline; allow 1 in. extra for overlapping. Stitch two rows of ribbon wire to the net, wrapping over the ends of wires 1 in. where they join. Cut a crossway piece of velvet three times the width of the net bandeau. Turn in upper edge of velvet, bring up the bottom side with the raw edge turned in, and slip stitch.

A straight bandeau is made in the same way, except that the ends are not joined. Turn over ribbon wire for $\frac{3}{4}$ in. each end. Cover with velvet, oversewing the raw edges closely, without turning them in.

"Chip" bandeaux are mostly used for fronts of open-fronted bonnets, and are made about 11 in. long, wired all round. Stretch the chip along the outer edge and contract along the bottom edge. At each end, turn it into half its width.

To sew the bandeau to hat, pin it in the right position. Use strong cotton and the long backstitch, keeping the long stitches on the outside of the bandeau. Catch the bottom wire of bandeau to the headline or brim of hat.

Continued

THE TREATMENT OF RIVERS

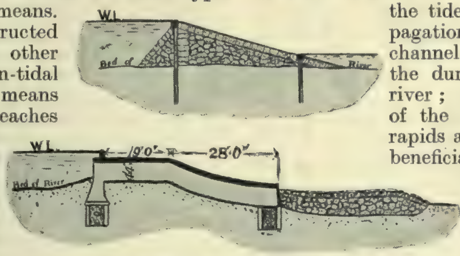
Hydraulic Works on Tidal and Non-tidal Rivers and in Estuaries. Training a River. Systems of Dredging

Group 11
CIVIL ENGINEERING
37
HYDRAULICS
continued from page 5116

By Professor HENRY ROBINSON

STEVENSON has given the chief engineering works that are necessary for the improvement of rivers to assist navigation—in the non-tidal part the construction of weirs to dam back the water, thus forming stretches of canal; in the tidal branches, the straightening, widening, and deepening the beds, and the erection of walls for the guidance of the tidal currents; in the seaward part, the removal of bars and shoals.

Careful consideration must be given to the material of the bed in order that it may not be eroded by any increased velocity, unless that is the object to be attained. Care must also be taken that the works carried out on the tidal portion do not interfere with the discharge of the non-tidal part, as the result would be the flooding of the land in the upper reaches in time of maximum discharge. In large rivers (such as the Mississippi) the difficulty is not so much the decrease in depth due to the minimum flow, as the control of the water in times of flood, to prevent damage to the land adjoining. In this country, the rivers are not of sufficient size to make the work in the non-tidal part of the importance it has abroad, and they can be made deep enough for canal barges and boats of that type only by artificial means. Weirs have been constructed (on the Severn and other rivers) across the non-tidal portion of streams by means of which the upper reaches have been deepened, thus allowing barge traffic to be carried on. When this is done, it is necessary that these weirs be of sufficient length not to retard the flow in times of flood.



7. WEIRS ON RIVER SEVERN

Sir William Cubitt adopted the practice on the Severn of placing the weirs obliquely across the channel, and making the weir of a length that the rectangle formed by its length and its depth below the flood line should be equal to the rectangle of the river above the weir within the same flood limits. Fig. 7 shows forms of weirs used in the Severn.

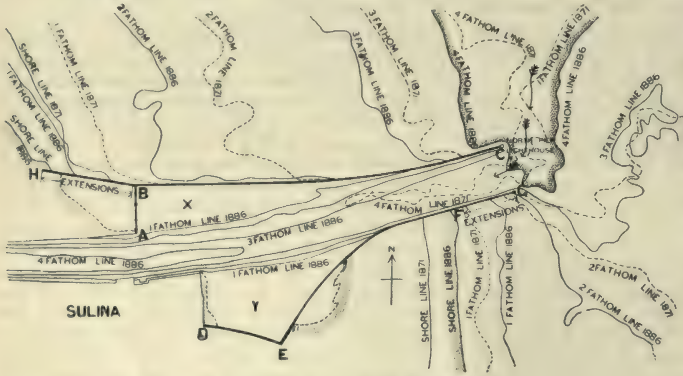
Tidal Rivers. The term *tide* implies the action of the ocean water in rising and falling, and is due to the force of attraction of the sun and moon on the water of the earth's surface. Tides are divided into spring tides and neap tides, the high-water level of the former being greater than the latter, and the low-water level is generally lower. This difference of level is the vertical rise above mean low-water of spring tides. The *range* of the tide is the vertical difference between high and low water of any tide. The navigable rivers in this country may be regarded simply as being formed and kept open mainly by the action of the tide, and our chief ports are practically dependent on tidal navigation.

The conditions of a river under the influence of the tide are that it has a regular flow and ebb, usually taking place twice a day. The tidal portion of the river is that which is affected by tidal action during the rise of an ordinary spring tide, and not that which is occasionally affected by extra high tides. The tides in estuaries are propagated from the great tide wave of the ocean. The laws of propagation, which are somewhat obscure, were first investigated by Mr. Scott Russell, who showed that the passage of tides through estuaries is quite distinct from the tidal current. The current which flows into the river is due entirely to the slope or fall on the surface of the water. The amount of this slope depends on the rapidity with which the tide rises and the degree of obstruction presented to its propagation up the river. Stevenson summarises the principles for works of improvement of rivers as follows: to deepen the level of the low-water line; to increase the range of the tide; to accelerate the propagation of the tide through the channel of the river; to prolong the duration of the tide in the river; to equalise the velocity of the tidal currents, removing rapids and bores; to add to the beneficial scouring power of the river, and to increase the navigable depth.

The Engineer and Tidal Rivers. In dealing with the tidal part of rivers, the object of the engineer is to facilitate the propagation of the tidal wave, the result of which is to increase the tidal influence, and to prevent the heaping up of the waters in the lower reaches during flood tides. This heaping up of the water in the lower reaches is due to the circuitous course of the river, the projection of obstacles from the banks, and various other causes. The result is to check the propagation of the tide-wave, and, where the tide rises rapidly, to heap up the water at the mouth and cause a bore, due to the early waves of flood tide being retarded so much that they are overtaken by the succeeding ones, or, in other words, the water is heaped up until a slope is formed, causing the succeeding waves to ascend the river in the form of a breaking wave.

The deepening of the bed, and consequent lowering of the low-water line, allows the tide

to extend further up the river. If the non-tidal section be made sufficiently large to carry off the occasional floods, the velocity in ordinary times will not be sufficient to prevent detritus depositing, and the bed filling up again, unless the section thus obtained is affected by tidal action. In flood times, the upland water will displace a certain amount of the tidal water for the time being, thus remaining in the river bed instead of flooding the surrounding country.



8. TRAINING OF THE DANUBE

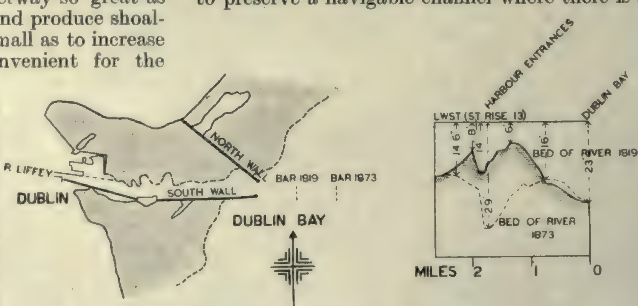
The removal of all obstacles to the flow of the tide is the object to which attention has chiefly to be directed in designing improvements in the department of navigation. In order to form a satisfactory opinion it is necessary to have an accurate survey, showing the depths of the water and the breadths of channel throughout the whole extent of the river, as well as the amount of tidal range, the velocity of the currents, the rise on the bed, and the nature of the materials of which the bottom and banks are composed.

It may be laid down as a general principle in designing works for river improvement, on the one hand, not to adopt a waterway so great as to reduce the scouring power and produce shoaling, or, on the other hand, so small as to increase the current beyond that convenient for the proper management of vessels.

Effect of Improving Tidal Rivers. The tide, in improved rivers, begins to flow earlier than it did before, and a larger body of water is carried up the navigable channel, where its effect is most useful, but the same works which increased the propagation have, by removing obstructions, decreased the heaping up of the tide, and, consequently, the velocity of the tide current. Wheeler gives the following conditions as being essential for a tidal river in good order :

1. The tidal wave at the foot of the tide should be propagated at a rate of not less than 10 miles an hour.

2. The level of high-water should not be lower at the port up the river than at the mouth.



9. TRAINING OF THE LIFFEY

3. The duration of the tide—that is, from first flood to high-water—should not be less than from four to five hours.

4. The velocity of the tidal current should not exceed $2\frac{1}{2}$ miles an hour.

5. The depth at low-water should be sufficient for the navigation of the ordinary craft frequenting the port, and at mean high-water should allow 2 ft. under the keel of the largest vessels.

6. The width should diminish from the mouth upwards, the progressive widths being greater in proportion at the lower end than the upper.

7. The channel should not have in it curves of a radius less than 2,500 ft.

8. The section of the channel should be large enough to allow the upland waters in floods to flow down at a velocity that will not materially interfere with the navigation.

Non-tidal Rivers. In non-tidal rivers, training works have for their object the regulation of the channel, in which the volume of water flowing downwards to the sea varies at different times. In rivers above the range of the tide, or where they flow into tideless seas, training works preserve the channel from the tendency of the suspended matter in the water to deposit, due to the reduced velocity, as is the case where rivers widen out or where they meet the tideless sea. In tidal rivers the conditions differ from the foregoing, inasmuch as the fresh water volume or flow is affected by the tidal flow both in ebb tide and flood tide. Where a river flows through a tidal estuary, the problem to be dealt with is to preserve a navigable channel where there is a tendency to form banks, frequently shifting and varying in their positions, and therefore proving a source of difficulty if not of danger to navigation. Rivers in their natural state usually vary in width, depth, and in direction. The object of training works is to maintain uniformity in the width and depth of the navigable channel. Much consideration is required in settling

the nature of the works to effect the contemplated improvement of a river channel. For instance, it is possible to improve one part of a river by removing shoals, but at the same time deposits may be occasioned elsewhere. This is often caused by the erosive action of an increased velocity of current (due to the training works) removing material from the bed or sides of a river, and these may deposit beyond the range of the training works.

10. BUCKET DREDGER

Estuaries. The entrances to tidal rivers are liable to have bars formed across them owing to the drifting of detritus along the coast, and its deposition, unless the combined land and tidal water at the ebb is able to carry it away seaward. Where this is unable to be done, training walls can be constructed which confine the river in a defined channel, and preserve a velocity and volume sufficient to scour the material seaward into deep water and into currents passing to the sea.

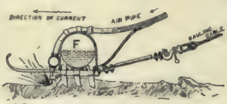
In some cases the material forming shoals and bars, being in a condition too hard for the scour of water to remove, may have to be dredged away in the first instance, after which the natural flow of the river, confined within the artificial training works, would suffice to prevent deposits. The height to which these training walls are carried must depend to some extent on local circumstances. Their main object being to direct the low-water current, it is found that they are generally most effective when carried up to a height equal to half-tide level. The greatest velocity of tidal water is at half-flood and half ebb. The flood tide has a greater erosive action than the ebb. The reason is that, salt water being heavier than fresh, at the beginning of the flood tide the salt water forces its way under the fresh, thus setting up an erosive action disturbing the particles in the river bed, which are removed by the ebb tide. Where the entrance to a tidal river is wide, and has shallow bights, or areas covered and uncovered at flood and ebb, training banks, or reclamation banks, may improve the river by directing the volume of the flood in a more defined channel, whereby the flood water may be carried higher up the river, and the returning ebb water may not be dissipated over these bights, but may be directed in a better channel seawards. In some cases the existence of natural bights, or indents, in the upper parts of a tidal river, and within reach of the tidal range, are valuable, as the water collected therein comes down to the entrance of the river towards the end of the ebb and helps the scour at low ebb. Sometimes artificial reservoirs are made up-stream to collect tidal water at flood tide to accomplish this.

11. GRAB DREDGER
(Used by Armstrong, Whitworth & Co., Ltd.)

Training a River. An example of the successful training of a river is that of the Sulina mouth of the Danube [8]. These training works, extending a mile from the shore line, were carried out beyond the site occupied by the bar, and thus concentrated the scour of the current right across the bar. The depth of water over the bar was thereby increased from 10 ft. in 1857 to 20 ft. in 1872, and this depth has since been maintained. The walls were of a temporary nature to start with, formed by an outer row of close piling with two inner rows of ordinary piling supporting a platform of timber 4 ft. above the sea level, with stones deposited on each side of the close piling. A solid

concrete superstructure 10 ft. wide ultimately replaced the timber structure. The concrete (formed of one part cement to three parts sand and gravel) was deposited in movable wooden frames up to the water level. Above this the concrete was made of one part cement to six parts of sand, gravel and stones. As the work progressed seawards, the foundations were prepared by divers, and then concrete blocks weighing 18 tons were lowered into position and their interstices filled with newly-made concrete. One other illustration will suffice to show how the objects of training works are attained.

Figure **9** shows the improvement in the River Liffey due to training walls. The bar was caused by littoral drift. The wall for about half of its length is 6 ft. above high-water level, thence dropping to high-water level, and then gradually sloping to below low-water level. By the construction of these walls the velocity of the ebb tide was increased from 1¼ miles to 3 miles per hour, and produced an increased depth of 7 ft. over the bar in the first thirty years. The whole wall was not built above high-water level because, if it had been, there would have been a strong current bearing sand during the first half of the ebb tide, and this, meeting the opposing current from the bay, would deposit the sand and form a shoal.



12. SCOURING DREDGER

Dredging. If the current, however, fails to scour away the bar, dredging has to be resorted to. Should the material be very solid, such as rock, blasting is necessary to loosen the materials, which can then be dredged.

There are several methods of dredging, which may be classified as follows:

(1) Bucket dredgers.
(2) Grab dredgers.
(3) Eroding and scouring dredgers.
(4) Pump and suction dredgers.
(5) Rock-breaking dredgers.

The illustration [**10**], reproduced from "Engineering," shows a bucket dredger.

An hydraulic grab dredger is shown in **11**. This type of dredger is very useful for removing gravel or similar material.

Eroding and Scouring Dredgers. Harrows of different descriptions, and also specially designed ploughs, have been employed with success. They are towed over the bed of the river and break up the soft material, which is then scoured away by the current. Air and water, forced into the silt or fine sand, has a similar effect. Figure **12** shows a method of scouring produced by compressed air. The float, F, serves the purpose of preventing the plough from sinking too far into the mud.

Pump and Rock-breaking Dredgers. The use of pumps for dredging has been successfully employed in various localities. The presence of stones, etc., causes a great deal of damage to the pumps, consequently restricting their use to places where only mud, or very fine sand, is to be found. The ball pump was invented to prevent this damage. The material, which is received at the centre, is brought by a spiral duct into the shell of the pump. This duct transforms the motion of the material into a rotary one in the same direction as the blades of the inner fan. The material on passing through the fan leaves the blades tangentially. This form of pump is distinct from the ordinary centrifugal pump.

When rocks have to be removed, and where it is inadvisable to employ explosives, heavy rams, with chisel points, are used. These rams pulverise the rock, which is then removed by bucket or grab dredgers.

Excavating Large Canals. In a paper on the Panama Canal, read by M. Philippe Bunan-Varilla, before the London Society of Arts, in January, 1907, some interesting figures were given of the uses to which dredgers can be employed for the excavation of large quantities of material. Until quite recently, when it became necessary to excavate vast quantities of material for canal purposes, the steam navvy has been employed for discharging the excavated material into trucks running on rails. When it becomes necessary, as for the purpose of a canal like the Panama Canal, where the country is frequently visited with heavy falls of rain and the attendant disorganisation of the system of road carriage and excavation on land, owing to the washing away of the lines, etc., it becomes an important problem whether this cannot be done better by water-borne dredgers resulting in a great saving of expense.

In the paper referred to, part is devoted to this problem, and it is suggested to carry out the construction of the work on the lines indicated above. The material, after being dredged, is emptied into barges and is transported by them into deep water, when by opening traps in the bottoms of the barges the material is got rid of. It was stated that a barge was capable of carrying 1,000 cubic yd., and that the dredgers were able to excavate 14,000 cubic yd. per day under the most unfavourable conditions. In the excavation for the Manchester Ship Canal by the Lobnitz process of rock drill, the cost, according to Mr. Hunter, was 9d. per cubic yd. The excavation for the Bitter Lakes of the Suez Canal for the purpose of deepening the Canal was carried out at a cost of 1s. per cubic yd., by means of dredgers, without explosives and without interrupting the traffic.

Continued

RATIO AND PROPORTION

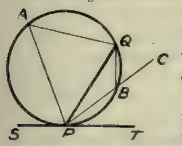
Rectangles in Connection with Circles. Simple Theorems from Four Proportionals. Proportional Division of the Sides of a Triangle

Group 21
MATHEMATICS
37
GEOMETRY
continued from page 5198

By HERBERT J. ALLPORT, M.A.

Proposition 50. Theorem

The angles which any chord of a circle makes with the tangent at its extremity are equal to the angles in the segments into which the chord divides the circle.



Let PQ be a chord of the ⊙ PAQB, and SPT the tangent at P.

It is required to prove that

$\angle$ QPT = $\angle$ PAQ, in the segment PAQ,
and $\angle$ QPS = $\angle$ PBQ, in the segment PBQ.

Proof. Produce PB to C. Then PAQB is a quadrilateral in a ⊙.

∴ $\angle$s PAQ, PBQ are supplementary (*Prop.* 41).

But $\angle$s PBQ, QBC are supplementary.

∴ $\angle$ QBC = $\angle$ PAQ.

Now, let the point B move up to P. PC will then coincide with PT, and the $\angle$ QBC with the $\angle$ QPT.

∴ $\angle$ QPT = $\angle$ PAQ.

Again, $\angle$s QPS, QPT are supplementary, and the $\angle$s PAQ, PBQ are supplementary. And it has been shown that $\angle$ QPT = $\angle$ PAQ.

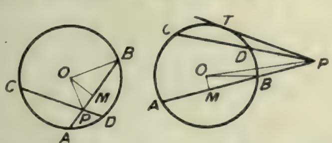
∴ $\angle$ QPS = $\angle$ PBQ.

Definition. If a point P is taken in a straight line AB, the point is said to divide AB into two *segments* AP and PB. If the point P lies between A and B the line is divided *internally*; if P lies in AB produced, the line is divided *externally*.

Proposition 51. Theorem

If two straight lines drawn through any point P cut a circle in A, B and C, D respectively, then the rectangle AP . PB is equal to the rectangle CP . PD.

Let ABD be a ⊙ whose centre is O. Through



the point P draw any two straight lines cutting the ⊙ at A, B, C, D.

It is required to prove that rectangle AP . PB = rectangle CP . PD.

Proof. Draw OM ⊥ to AB. Join OP, OB. Then OM bisects AB (*Prop.* 36).

Now, when P lies within the ⊙,

Rectangle AP . PB = (AM − PM) (PM + MB)
= (BM − PM) (BM + PM)
= $BM^2 - PM^2$
= $(BM^2 + OM^2) - (PM^2 + OM^2)$
= $OB^2 - OP^2$
= square on radius − OP^2.

In the same way it can be proved that

Rectangle CP . PD = square on radius − OP^2.

∴ rectangle AP . PB = rectangle CP . PD.

Similarly, when P is outside the ⊙, we get

Rectangle AP . PB = OP^2 − square on radius
= rectangle CP . PD.

Corollary. In the case when P is outside the ⊙, suppose CDP revolves about P; the points C, D then approach one another until they coincide, and CDP becomes a tangent to the ⊙. The rectangle CP . PD becomes the square on the tangent from P. Hence we have:

If the tangent to a circle at any point T meets a chord AB in P, then $PT^2 = PA \cdot PB$.

NOTE. By a method similar to that of *Prop.* 42 we can prove the converse of *Prop.* 51—*viz.*, *If when two straight lines AB, CD intersect in P, the rectangle AP . PB = the rectangle CP . PD, and the four points A, B and C, D are both on the same or both on opposite sides of P, then A, B, C, D are concyclic.*

Again, the converse of the above corollary is true—*viz.*, *If from a point P in the chord AB a straight line PT can be drawn to the circle so that $PT^2 = PA \cdot PB$, then PT touches the ⊙ at T.*

For, suppose the ⊙ cuts the straight line PT again at T′. Then PT . PT′ = PA . PB (*Prop.* 51) = PT^2 (*Hyp.*).

∴ PT = PT′, so that T and T′ coincide.

∴ PT is a tangent.

RATIO AND PROPORTION

Ratio. Two quantities *of the same kind* can be expressed in terms of a common unit. Suppose the first quantity contains this unit *a* times, and the second contains it *b* times, then the ratiio of the first quantity to the second is the fraction $\frac{a}{b}$.

The ratio is generally denoted by $a : b$.

a is called the *antecedent* and *b* the *consequent* of the ratio.

Proportion. Four quantities are in proportion when the ratio of the first to the second is equal to the ratio of the third to the fourth.

Thus, if *a* is a *length* of 1 ft. 9 in., *b* is a *length* of 2 ft. 4 in., *c* is an *area* of 6 sq. ft., and *d* is an *area* of 8 sq. ft., then the ratio $a : b$ is the fraction $\frac{21}{28}$, or $\frac{3}{4}$; the ratio $c : d$ is the fraction $\frac{6}{8}$, or $\frac{3}{4}$. Therefore, since these ratios are equal, the four quantities *a, b, c, d* are in proportion. The proportion is denoted by $a : b :: c : d$.

a and *d* are called the *extremes*; *b* and *c* are called the *means*.

d is called a *fourth proportional* to the three quantities *a, b, c*.

Three quantities are said to be proportionals when the ratio of the first to the second is equal to the ratio of the second to the third. Thus, a, b, c are proportionals if $a : b :: b : c$.

c is called a *third proportional* to a and b.

b is called a *mean proportional* between a and c.

Continued Proportion. If any number of quantities be such that the ratio of the first to the second, the ratio of the second to the third, the ratio of the third to the fourth, and so on, are equal to each other, the quantities are said to be in continued proportion.

Thus, quantities in continued proportion are also in *geometric progression*. [See page 3914.]

Four Proportionals. When a, b, c, d are in proportion, we know that $ad = bc$. [See page 3695.]

The following results are also easily obtained:

(1) $b : a :: d : c$
(2) $a : c :: b : d$
(3) $a+b : b :: c+d : d$
(4) $a-b : b :: c-d : d$
(5) $a+b : a-b :: c+d : c-d$.

For example, since $a : b :: c : d$, we have

$$\frac{a}{b} = \frac{c}{d}.$$

Therefore, $$\frac{b}{a} = \frac{d}{c},$$

i.e., $b : a :: d : c$.

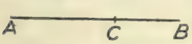
Again, we know

$$\frac{a}{b} + 1 = \frac{c}{d} + 1,$$

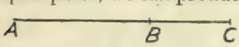
so that $$\frac{a+b}{b} = \frac{c+d}{d},$$

which gives us (3). In a similar way we obtain (4). By dividing the result (3) by (4) we obtain (5).

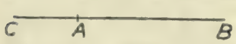
Division of a Line in a Given Ratio. A straight line AB is said to be divided *internally* at C in the ratio $a : b$, when AB can be divided into $a + b$ equal parts, of which AC contains a, and CB contains b.



Again, if $a > b$, and AB is divided into $a - b$ equal parts, we can produce AB to C so that BC contains b of these parts. We then have AC : BC :: $a : b$, and AB is said to be divided *externally* at C in the ratio $a : b$.



Similarly, if $a < b$ and AB is divided into $b - a$ equal parts, we can produce BA to C so that AC contains a parts. We then have AC : BC :: $a : b$, and BA is divided externally at C in the ratio $a : b$.



Proposition 52. Theorem

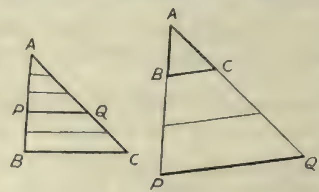
If a straight line is drawn parallel to one side of a triangle it cuts the other sides proportionally.

In the Δ ABC let the straight line PQ be drawn || to BC, cutting AB in P and AC in Q.

It is required to prove that

AP : PB :: AQ : QC.

Proof. Suppose that AP : PB :: $a : b$. Then, if AP is divided into a equal parts, PB can be divided into b of such equal parts. Through all the points of division draw straight lines || to BC.



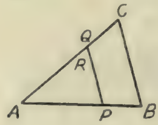
Then, AQ will be divided into a equal parts, and QC will be divided into b of such equal parts; that is,

AQ : QC :: $a : b$.

$\therefore$ AP : PB :: AQ : QC.

Proposition 53. Theorem

If a straight line cuts two sides of a triangle proportionally, it is parallel to the third side.



Let a straight line cut the sides AB, AC of the Δ ABC in P and Q so that

AP : PB :: AQ : QC.

It is required to prove that PQ is || to BC.

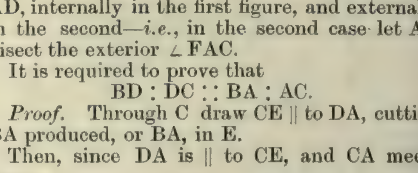
Proof. Draw PR || to BC, cutting AC in R.

Then AP : PB :: AR : RC (*Prop.* 52).
But AP : PB :: AQ : QC (*Hyp.*).
$\therefore$ AR : RC :: AQ : QC.
$\therefore$ AR + RC : AR :: AQ + QC : AQ;
or AC : AR :: AC : AQ.
$\therefore$ AR = AQ.
$\therefore$ Q and R coincide, and PQ is || to BC.

Corollary. If AB : AP :: AC : AQ, then PQ is || BC.

Proposition 54. Theorem

If an angle of a triangle is bisected, internally or externally, by a straight line which cuts the opposite side, or that side produced, the ratio of the segments of that side is equal to the ratio of the other sides of the triangle.



Let the $\angle$BAC of the ΔABC be bisected by AD, internally in the first figure, and externally in the second—*i.e.*, in the second case let AD bisect the exterior $\angle$FAC.

It is required to prove that

BD : DC :: BA : AC.

Proof. Through C draw CE || to DA, cutting BA produced, or BA, in E.

Then, since DA is || to CE, and CA meets them,

$\therefore$ $\angle$DAC = $\angle$ACE;

and, since AE meets the ||s,

$\therefore$ $\angle$DAF = $\angle$CEA.
But $\angle$DAC = $\angle$DAF (*Hyp.*).
$\therefore$ $\angle$ACE = $\angle$CEA.
$\therefore$ AE = AC.

Also, since AD is || to one side of the Δ BCE

$\therefore$ BD : DC :: BA : AE.
$\therefore$ BD : DC :: BA : AC.

Continued

THE MAKING OF SADDLES

The Saddler's Masterpiece. The Riding Saddle. Details of the Making of Cart and Van Saddles. Various Accessories. Application of Machinery

continued from page 5192

By W. S. MURPHY

WE have reached the stage where the materials and manufacture of all kinds of saddles may be considered. Figures **14** to **18** illustrate many of the operations in making saddles, the photographs having been taken in the works of Messrs. Middlemore & Lamplugh, Birmingham. The ironmongery required comprises saddletrees, stirrups, terrets, buckles, nails, and other smallware.

Cutting Out. The sizes and forms of saddles vary a good deal, and we cut them to pattern, grading to size. The main parts of each kind of saddle are as follow:

Riding Saddles. Seat, skirts, flaps, panels, stirrup leathers, gullet piece, welts, and trimmings. Textile parts: Webbing and linings of various kinds.

Cart Saddles. Panels, panel covers, flaps, housings, girths.

Van Saddles. Flaps, panels, top covers, girths, straps.

The Saddler's Masterpiece. Everyone knows that the riding saddle is the finest product of the craft. To make a saddle that will be comfortable for both horse and rider and at the same time look well and wear well is no mean achievement. Fashion has a good deal to say in regard to the shape and appearance of saddles, and we therefore have a number of shapes. Some riders like a fore part, or gullet, low, and others want it high and slanting well towards the seat; some wish the seat broad and flat at the back, and others must have the cantle high and pointed. We have to adopt several styles and classes of covering, too. This does not refer to imitation instead of real hogskin, and other cheap devices. In all those we refer to, the seat is of hogskin; but some may be made with flaps and skirts of plain leather, others with skirts of hogskin and flaps of plain leather; kneecaps may be wanted or disliked; and it is seldom nowadays that an ordinary saddler is requested to make a saddle that is all hogskin from seat to kneecap. Most common is the saddle with the hogskin seat, plain leather skirts and flaps, without kneecaps, and this we shall build up bit by bit

Saddletree. Consisting of pommel, or gullet, cantle, or back, saddle bars, and stirrup bars, the saddletree forms the frame of the saddle. In choosing it, regard must be paid to the size and breadth of the horse; a saddletree too narrow for the horse will produce discomfort and injury, with consequent trouble for the saddler.

Foundation. Having stretched three lengths of good webbing, take the first piece and nail it in two lengths from saddle bar to cantle to form a triangular belt; stretch the second piece across and nail it down, leaving a large piece hanging free; the third bit, which may be of inferior quality, is nailed close to the first webbing, and joined by sewing. Cover all over with two pieces of linen and tack down tightly. Make two pads of basil leather stuffed with flock, and nail to the edge of the tree, from the cantle forward. With white serge cover the seat all over, nailing and stitching down to the shape of the seat. Make a hole in the serge covering at the centre; secure it from unravelling by waxing the sides of the cut; then stuff with flock, stuffing through the hole till all is firm and even; next close up the hole.

14. RIDING SADDLE MAKING

Seat and Skirts. Damp the fine bit of hogskin cut for the seat, and nail it on the saddletree, in such a way that the nail marks will not be visible. Shape it, and pull back over the cantle, reducing the wrinkles to two one on each side. Leave the seat to dry.

Trim the skirt leathers. Sew on to the under sides pieces of lined leather to connect the skirts with the saddletree. Cover over both skirts with hogskin, stitching down with fine yellow silk. The seat is dry by this time. Shave it all round with a slight skive. Put skirts and seat together, and mark for sewing. Stitch a welt on each of the skirts; then sew skirts, welts, and seat together. Preparatory to adjusting the seat, the projecting points of the tree before the saddle bars must be covered with thin hogskin or basil. Make the seat damp, adjust it and the flaps on the saddletree, and nail down at the front; nail down the side pieces we joined to the skirts, and see that the saddle is kept straight. Pull the leather and the web straps forming the foundation over together, and nail them on to the saddletree.

Flaps. Line the flaps with serge and form the pads. Lay the flap on its place under the skirt on the saddletree, mark the points to

be cut, and make the nicks required. Fasten each flap in position, so that the pads may come loose under the corners of the skirts. Run a few stitches through the web and side piece; drive a nail through the fore part into the

15. MAKING HARNESS SADDLES

saddletree, and another in the tree at the back; slant both nails and clinch them.

Pommel. The gullet, like Mrs. Hubbard's cupboard, is bare, and to cover it we form a gullet-piece out of a plain bit of leather the length of the pommel and an inch wide, and a bit of hogskin slightly wider. Make these into a binding by joining them together over a cord and fasten the binding over the pommel. Join to the points of the flaps by driving silver staples, one leg through the gullet-piece and the other through the flap point, right to the neck in the saddletree. Conceal the joint of the gullet-piece, or pommel cover, with the flaps by pasting neatly over each join a piece of hogskin, skived away at the sides to make an apparently flat surface.

Girth Straps. Cut six straps 13 in. by 1 in. and crease in the usual way. Fold back the web and leather we left hanging, and sew two straps on each side, nailing the other two, one on each side, to the saddletree. Make two peaked flaps, called underskirts, and nail one on each side under the girth straps.

To finish off the body of the saddle we must put in a little bit of leather here and drive a nail through there, in ways which are obvious in practice, but rather too minute to describe.

Panels. Mark carefully the lines of the panel on both sides, and trim to size. Paste on the top lining, and let dry. Lay on the underlining of serge, large enough to allow for stuffing, and tack it on; sew right round and stuff. Quilt the lining. Mark lines across the panel flaps, and quilt over. On the fore ends of the panel two pockets are made for the points of the tree. When setting, push the points well into the pockets; tack the panel close around the front of the pommel; drive two tacks in between the points of the crupper loop at the end of the saddle. In addition, put three nails through on each side; one about 8 in. from the cantle end, one about the middle and one at the front.

Stirrup Leathers. Saddles without stirrups are incomplete. No new or special method is involved in the making of these; they are simply heavy straps designed to hold the stirrup irons. Unlike most straps, the stirrup leathers are worn flesh side outwards, and this has to be remembered when creasing and bending the buckle chape. The buckle is simply sewn into the thick end of the strap, and the holes are punched. Thread the strap through the stirrup iron, and hang on the stirrup bars on the saddletree. On the last, inventors have exercised their ingenuity to find a strong iron which would allow the stirrups to go when the rider happened to fall off. Many a rider who has lost his seat would have come off scatheless but for the drag of the stirrup in which his foot has become entangled.

Cart Saddletree. Various forms of cart saddletree have been made, but in main lines there is very little difference between them. You have always the curved double back with the two boards fixed flat under it. On this skeleton we have to build our saddle.

Panel. Cut the panel ½ in. longer than the boards, and 2 in. wider than the central width. Make both sides alike, and whip together, cutting an inward slant on the fore part. Smooth down the stitches, and lay under the saddletree; mark where the centre of each board touches the panel; on the marks sew a tag of leather for nailing on to the boards at the proper time.

Lining. Cut and shape a lining of strong woollen check cloth to both undersides of the panel; stitch on to the lining the leather basil facing for the panel; sew both on to the panel. Slit the lining in the centre of the panel. Draw a line on both sides, beginning about 1½ in. from the centre join of the panel and running out to 2 in. wide at the front. Tack the lining underneath, keeping the slit in the centre. Put a bound wisp of straw 9 in. long in the centre across the gullet, and after drawing the basil facing back on the marked lines, stitch the wisp firmly from above. Stitch the lining

16. MACHINE SEWING SADDLE FLAPS

on to the panel along the lines marked, leaving an opening in the centre.

Stuffing. Lay the panel on the bench, with the lining uppermost, and nail the corners. Now stuff the straw regularly in through the slit on the lining. When fairly tight, level down, and make a space evenly between the lining and the stuffing. Into this thrust a layer of

flock, and level down the whole pad. Do the same on the other side and so make the panel complete.

Crupper Dock. To join the crupper to the saddle, we must have some kind of link. A simple, though not very satisfactory, device is the nailing of a strong belt on the centre of the saddletree. This necessitates a buckle on the crupper, while the dock needs only the crupper put round it. Make the dock four plies of leather, sewn into one over two tinned rings, two plies, of course, going on each side of the rings. Bend the dock so as to point the ends on to the saddletree boards. Into the boards drive two staples, one on each ring, and clink the dock to the saddle.

Flaps. Cut the flaps 9 in. deep and 1 in. longer than the boards. Measure on the saddletree for the openings to let through the two girth straps; cut out the openings; edge all the sides and edges of the flaps, and race three lines round the sides. Make the fore girth 4 ft. 10 in. long, and the back girth 5 ft. 2 in.; edge, race, crease, black, and polish; turn down the chapes; stitch in the buckles, and form the loops, adding two running loops. Set the flap now in position, and tack each end on the board; run the girths into the openings left for them; nail flaps and girths down on to the boards.

We are slowly building up our cart saddle. The flaps, girths, and dock are in position, and now comes the turn of the panel, with its needful pads. Having placed the panel, nail the tabs which were sewn on the panel sides, front and back, firmly on to the boards.

Housings. Simple as the housings appear, mere covers for the top sides of the saddletree, the man who is careless with them always comes to grief. Cut both to lie the full length over across the saddletree, and between 5 in. to 7 in. broad. The back housing should be bulged out to the middle in shape, while the front one may be curved inwards on the outer edge and

17. FINISHING RIDING SADDLES

must be straight to lie close to the ridge in the middle at the inner side. Nail both down on the saddletree in the centre; then pull out to the sides, and tack down so that the surfaces will be smooth and firm. Drive in nails all round, about 2 in. apart, keeping the edges flush with the edges of the saddletree. Stitch down at the four corners on the flaps; ornament with either brass beading or fine leather held on by fancy nails.

Van Saddles. Though the saddletree of the van saddle is almost a miniature copy of the cart saddletree, the making of the saddles must

18. STUFFING PADS FOR CARRIAGE HARNESS

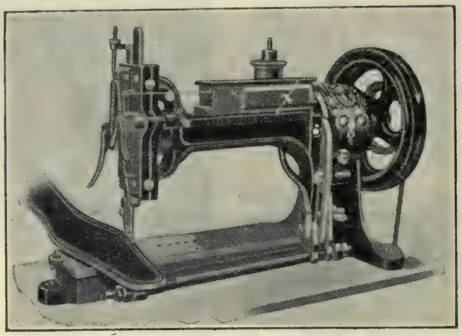
be learned separately. No man, after having been taught to make a cart saddle only, could undertake a van saddle. If he did, he would either show marvellous cleverness, if successful, or come to grief.

Saddletree. As a rule, saddletrees have to be trimmed a little; carefully shave to size. Fix the places for the bearing-rein, stand hook, and terrets, and bring the sockets down flush with the surface of the tree. For a covering of the saddletree, cut the pieces of thin leather selected for the purpose when gathering and cutting out the stuff; shape them to the sides of the tree, an inch overlapping all round. Lay on the saddletree, and into each make cuts the depth of the projecting boards, so that they will fold under the centre piece. Damp them; tack each end of the side pieces close to the board, and stretch very tightly over the whole surface; fasten with tacks here and there; pull the centre part well under the tree, and fix firmly with nails.

Flaps. The flaps should be made to fit the tree a few inches above the end of the centre groove, and the length may be about 15 in. Shape the pieces of patent or plain leather to the patterns, and note that they are right and left. This is important, for the fore side is rounded wider than the back. Race the lines for stitching on the lining; stitch a double row round. Clear the edges with the edge-tool, and polish; then join with a stitch at the top. Cover the joint front and back with a strip of leather, stitched on both sides and at the front. Put the tree exactly in position on the flaps, and mark for further operations. Indicate the width of the boards and the breadth of the saddletree on both sides. Lift off the tree, and slit the leather according to the lines. Now we are ready to fasten flaps and saddletree together. Make the centre slit meet the centre of the tree; nail the flaps along the sides of the tree, as close as possible; carefully adjust over the boards, and nail down.

Top Cover. Cut the top cover out of a piece of strong leather. Make it the same size

as the tree in width, and leave 2½ in. from the bottom, to allow space for the back band. Crease across both ends, and bevel with the heated bevel iron. Sew two rows across the points. But we must not smother the socket of the standhooks and terrets we put in not long ago. Place the top cover in position on the tree, and lightly tap it down with the mallet, thus imprinting the holes on the leather. Cut out the holes; then nail the cover on the tree, driving a strong nail into each corner. Run the beading along both sides of the top and through under the boards of the tree; tack on to the underside of the boards.



19. WAXED-THREAD SEWING MACHINE

Panels. Shape the body of the panel to about the same size as the flaps. Cut out of the same leather as the flaps a facing 1½ in. wide; tack it round the sides of the panel. Measure and cut the serge lining, and whip it to the inner side of the facing and to the bottom of the panel. Stuff the lining with carded flock, keeping it smooth and even. To make the sides of the panel stand out flat, fill up the inside of the facing with a thick cord or stiff wisp of straw right along. Rule lines 1½ in. apart on the panel, and stitch along the lines, making a quilting. Place the panel of the tree, and tack it in position. Having prepared some wires 5 in. long, pierce holes with a bent awl in the flap; pierce holes corresponding in the panel; draw the wire tightly through the holes, pulling flap and panel together; with the pincers twist the two ends of the wire; cut off the long ends, and thrust the knot into the hollow of the facing. Repeat this till the panel is fully secured. This work is also done by machine [19].

20. MAKING TRAVELLING BAGS

Make the straps and girths in the way before directed, and sew on to the bottoms of the flaps, the girth on the off-side, and the strap on the near side.

Saddles for gig, four-wheeler, and hansom, are built on the same principles, though the gig and four-wheeler saddles are simpler, and that for the hansom is lighter.

Accessories. Of the group of articles which we may designate *accessories* there is not much to be said.

Breastplate. Used for preventing the saddle from slipping back on the haunches, the breastplate consists of long side straps, bound over at the top by the neck strap, two short straps to be looped to the saddle, and a girth strap extending from the V-joint of the side straps between the horse's fore legs to the girth.

Martingale. This is a simpler breastplate, the body generally being made round, lying on the horse's neck like a hoop.

Saddle Girths. Girths are broad bands buckled round the belly of the horse to keep the saddle in position. They may be made of wool, mixed wool and cotton, leather lacing, and other materials, with leather ends and good buckles.

Saddle-cloths. Generally made of fine felt, the saddle-cloths are shaped to form a wide margin round the saddle, and bound with tape. They are meant to protect the back of the horse, and absorb sweat.

Head Collars. Various shapes of head collar are made; but none of them present any difficulty. The main principle of all forms is to combine headband, noseband, cheeks, throatlash, and chin-straps, in such a way as to make them easy to fit and put off and on, while keeping secure on the head of a restive horse.

Tugs. On the tugs the weight and strain of shafts and traces impose a heavy burden. Most important and representative is the shaft tug for van or cab. Cut a strip of strong leather about 2 in. broad, shave and edge it, then overlap 4½ in.; knock together, and make a hole through both leathers. Insert the buckle and brass loop, and stitch firmly the overlap. Pack tightly with hard sole leather, always keeping to shape. Put four rows of stitching through the whole body, leaving a space for the loop to be set in. Make the loop, and stitch in. Finish in the usual way.

Miscellaneous. There are a good many articles which the saddler and harness-maker must learn to make from mere practical experience. Knee-caps, fetlock boots, false collars, and horse clothing involve little that is new.

Machinery. We have touched but lightly on this side of the trade because the machine must always be merely the auxiliary of the craftsman in our work. The sewing machine is the chief mechanical operator with us, and it certainly saves a great deal of labour. Saddlers also make other items, such as bags, purses, portmanteaus [20], letter cases, kit bags.

SADDLERY AND HARNESS *concluded; followed by* GLOVE MANUFACTURE

CYCLOPÆDIA OF SHOPKEEPING

SPORTING GOODS DEALERS. Requisites for Outdoor and Indoor Sports. The Personal Element. Stock and Profit

STATIONERS. Varieties and Details of the Stationery Business. Stock Arrangement. Side Lines. Profits

SPORTING GOODS DEALERS

It is certain that the trade in articles requisite for the pursuit of sports is increasing. The object of this article is to show how a trade in such requisites may be done and the way to do it. Other articles in this section have dealt with Fishing-tackle Dealers [page 2524], and Gun and Ammunition Dealers [page 3149], so that it is unnecessary to refer to these here.

Idiosyncrasies of the Trade. It must not be imagined that the selling of goods required for English sports and games is a simple matter; it is far from that. As a matter of fact, it is not generally carried on alone. More often than not it is an auxiliary to the business of a hair-dresser, a saddler, a tobacconist, or an ironmonger. For it must not be forgotten that there is a dead season in outdoor sport, and it is therefore almost imperative for anyone undertaking the business in sporting goods alone to endeavour to work up a trade in indoor games of all kinds as well. Moreover, there are in all the big towns and cities the departmental stores, with their sports departments, to compete against. Then, again, the professional cricketer, or the professional golfer, who manufactures his own bats, or his own golf clubs, is a formidable rival. It is absolutely necessary that the man who desires to make a success of the business must know not only one game thoroughly, but every other game well. He must know not only how to play football, tennis, cricket, croquet, hockey, etc., but he should be conversant with the laws of all the games. If he is an expert at cricket or golf, so much the better, but at least he should be a safe man to consult regarding regulations, and naturally he would make it his business to know all that is going on in the world of sport covered by his trade.

The Practical Training. Even with all the attributes mentioned, actual experience in the commerce of the goods is necessary. This is not learnt in the playing fields, or in the actual workshops where the goods are made. It is seldom that a man from the factory starts in business on his own account. Sometimes a professional footballer, cricketer, or golfer may give up the field for the road and get a position as traveller for a large wholesaler or manufacturer of sporting goods. Such a man may obtain sufficient insight into the intricacies of the business to justify him in starting on his own account. The best experience is to be obtained by going as a youth into a big wholesale and manufacturing business which does a miscellaneous trade in goods for outdoor and indoor games, and "working up." There is no recognised apprenticeship system in the trade, and the youth who goes as errand boy has the same opportunity, provided he has equal intelligence, as the youth whose father can pay a premium for his experience. Failing the possibility of such a training, the business may be efficiently absorbed by the alert youth in the sports department of a large stores.

Utilising the Training. The buyer of sporting goods for the department of a large stores is a position worth trying for. In some of these departments they specialise in tennis, hockey, cricket, and so on; and if the buyer knows all there is to be known about footballs, for instance, he may make a reputation for his house as the house for footballs. But many young men prefer a more independent line, and hanker after businesses of their own. So one with a genuine love of sports, a good all-round experience, and a fair share of business acumen, who has a capital of at least £200, would look around, in the country towns more particularly, for a desirable opening. There are few country towns or even villages nowadays that have not one, or several, cricket, football, or golf clubs. Ladies' schools and seminaries abound, as well as boys' schools and training colleges, and these provide prospective customers. Hockey, tennis, lacrosse, and even cricket are as much a necessary part of the modern girl's school education as modern languages.

The Shop. In the matter of decoration and display, the establishment of the dealer in sporting goods need not be elaborate. This means that the size of the shop and the choice of the fittings are secondary considerations. The main things are the locality, the soundness of the stock, and, above all, the knowledge of the shopkeeper. A small shop, therefore (costing probably in a small country town not more than £30 to £40 a year rent, with living rooms attached), would be simply fitted with a few shelves and racks, a counter, lighting supply, and perhaps a glass wall case, the whole fixtures not costing more than £30 all told. A knowledge of manufacturing and mending is, of course, extremely useful, but this department is not actually necessary for a beginner, who can get all he requires done in that way by the regular recognised factories.

The First Stock. The choice of an opening stock must be determined by the needs of the neighbourhood, primarily, but it must also be general. In any case, it need not necessarily be large, but it ought to be varied. In the following table an attempt is made to give an approximate idea of the articles required, the quantities, the cost, and the selling prices. The prices given must, however, be distinctly taken as relative, and the man's experience will enable him to gauge the potentialities of the neighbourhood, so that the list given on the following page may be varied without increasing the outlay—about £70.

As will be noticed, the list deals only with the better-known and more popular outdoor games, and the selection may be regarded as representative of what an opening stock ought to include. It may be possible to buy cheaper and to sell dearer than the prices given, but these may be looked upon as fair average all round.

Peculiarities of the Stock. There are certain articles with which care must be taken in storage. A temperature below 32° F. will ruin good tennis balls, and billiard cues—of which more hereafter—will warp if not kept free from damp or if exposed to excessive heat. Tennis is very popular, and badminton is increasing in public favour annually. There are special manufacturers of known repute

Number	Article	Total cost	Retail price
		£ s. d.	
1 doz.	Tennis racquets ..	6 10 0	7s. 6d. to 27s. each
1 pair	Tennis poles	2 0 0	£3 per pair
4 doz.	Tennis balls	1 5 0	6d. to 1s. each
¼ doz.	Tennis nets	1 3 0	6s., 10s. 6d., and 14s. each
½ doz.	Croquet sets	6 0 0	£8 per ½ doz. sets
1 doz.	Croquet mallets ..	3 0 0	£4 per dozen
¼ doz. sets	Croquet balls	1 15 0	10s. 6d. to 21s. per set of 4
4 doz.	Golf clubs (selected)	8 16 0	4s. to 5s. each
1 gross	Golf balls (selected)	12 0 0	1s. to 2s. each
½ doz.	Golf caddies	1 17 0	2s. 6d. to 9s. 6d. each
¼ doz. pairs	Bowls	1 9 6	9s. 6d., 12s., 16s. 6d. pair
1 doz.	Cricket bats	4 10 0	4s. to 20s. each
1 doz.	Cricket balls	1 10 0	1s. to 5s. each
4 sets	Cricket stumps.. ..	9 6	10s. 6d., 2s. 6d., 1s. 6d., 1s. each
2 doz.	Footballs	5 10 0	3s. 6d. to 10s. 6d. each
2 doz.	Hockey sticks ..	6 0 0	4s. 6d. to 10s. 6d. each
2 doz.	Hockey balls	3 0 0	1s. to 5s. each

in each branch of the trade, so that the man who knows his business will be able to choose the proper make of tennis racquet, football, badminton bat and so forth, and be able to expatiate on the points of the article he is selling. Complete sets for badminton comprising bats, net with portable poles, shuttlecocks, etc., may be had to retail at from 15s. to 45s. per set. They show a profit of fully 25 per cent. Croquet is again coming much into fashion, and hockey is something of a rage at the moment with both men and women. Golf is usually a lean trade for the general dealer in sporting goods.

The professionals at the club-houses do it all, seeing that more often than not each pro. has his own make of club which he recommends to learners and to players alike. As for golf balls, their name is legion. The rubber-cored ball in its many varieties is generally regarded as the favourite, and a judicious selection is necessary, as a large stock is costly. Bowls is a difficult business to foster, but it is very popular in some parts of the country, particularly in Scotland. If there is any bowling club in the vicinity it might be diplomatic for the shopkeeper to join it, if possible, and to lay in a stock of two or three pairs of bowls for show purposes. But it is important that he should see that each bowl bears the official stamp of either the Scottish or the English Bowling Association. Cricket appeals mainly to the younger portion of the community, therefore the stock of bats should include an assortment varying in size and quality, so that all ages, from the schoolboy to the full-grown Oxford graduate, may be suited. It is not advisable to stock stumps largely; they usually last a long time and do not get lost like balls, or broken like bats. One or two junior sets should not be overlooked in ordering. It might be advisable to stock a few pairs of wicket-keeping gloves, leg-guards and batting-gloves, provided the neighbourhood is a cricketing resort, but it should be borne in mind that these goods are particularly liable to become shop-soiled. In footballs the No. 5 Association pattern is most generally sold.

Indoor Games. There are many indoor sports to be catered for, and as it is assumed that our young enthusiast is eager to make his field of action as comprehensive as possible, he might lay in a few billiard cues and billiard balls. Half a dozen cues, retailing at anything from 2s. 6d. upwards, would suffice, and two or three sets of balls. Then he might have half a dozen sets of chessmen of different patterns and qualities to retail at from 2s. 6d. to 12s.; the ten-guinea ivory sets would not be advisable at first. He might likewise provide a few sets of dominoes, draughts and draught-boards, backgammon sets, dice and dice-cups, playing cards, card counters, ping-pong sets, "Ascot" sets; and there are innumerable varieties of things like table bowls, table croquet, and variants on all kinds of outdoor games he might stock. A judicious outlay of £10 or £15 on the ingenious and amusing indoor games that are invented every year, and keep winter parties in good humour would well repay the careful buyer and would keep the dead season alive. As a matter of fact, just before Christmas is a favourable time for the beginner to open his shop, provided he can make a good display of inexpensive but alluring parlour games such as "Tiddledy Winks," "Go-bang," "Aunt Sally," "Ludo," "Puff and Dart," and so on. These things get the new man acquainted with the young people, and it is the younger generation which, after all, keeps the outdoor games a-going when the summer comes again.

The "Arts," Athletics and Other Adjuncts. It may be that devotees of the "noble art" reside in the neighbourhood, and a pair or two of boxing-gloves would be attractive. Or the military instinct may be prevalent, and a few fencing foils, fencing masks, gloves and gauntlets, single-sticks and single-stick helmets would not look amiss. Indian clubs are seldom out of place, and the physical culture craze has created a considerable demand for spring-grip dumb-bells, punching balls, exercisers, and developers, and such things as these, small stocks of which might be kept. If schools are a feature of the locality apparatus for calisthenics and musical drill might be requisite, while the time-honoured pastimes of childhood, like glass marbles, humming tops, skipping-ropes, peg-tops, teetotums, whipping-tops, and battledore and shuttlecock should never be lost sight of. An outlay of £5 in such miscellaneous things will make a show that will give delight to the youth of the neighbourhood. There are, of course, many other lines which the dealer may develop as the business grows and should there be a demand. Games like quoits and skittles are popular in some districts, while other neighbourhoods, or the vicinity of a military garrison, may induce the stocking of all the requisites for polo. Archery has a vogue in some parts of the country, but its popularity appears somewhat spasmodic and confined to enthusiasts.

Attracting Trade, and the Reward. The personal element is the strong point, and the young man should endeavour to become associated with as many of the local clubs as possible. Immediately after opening he should issue a trade catalogue, and his catalogue should always be a feature of the local sporting haunts. Large manufacturers of sporting goods, such as John Jaques & Son, Ltd., of Hatton Garden, London, supply excellent and comprehensive catalogues, with the name and address of their customers printed on the covers, for only a nominal sum. With regard to profits, it may be taken as a general rule that the average profit on the turnover comes out at from 25 per cent. to 30 per cent. The outlay is not great, there is little risk of deterioration of stock if ordinary care be taken, and the working expenses at first need not cost more than 5s. or 6s. a week, for a boy to keep things tidy and to run errands.

STATIONERS

The business of a stationer may be called one of the allied trades, because it is usually second in the trio of bookseller, stationer and newsagent. In fact, we find it associated with quite a variety of businesses, and it is a general opinion that anyone can be a stationer. If by stationer is meant handing across the counter a box of pens or a packet of notepaper and envelopes, then to a certain extent this is true. The real stationery business, however, is separate and distinct from all others, and requires a thorough, special training.

Apprenticeship. The term of apprenticeship is five years, and the pay usually begins at 3s. a week with an annual increase of two shillings a week. Of course, this may vary in some houses, but that may be taken as an average. To obtain a thorough training the novice should enter some good wholesale house where he will get a knowledge of all the departments and be initiated into the mysteries of the various sizes and qualities of papers, learn the trade terms, and be taught the difference, say, between a retree and a perfect, a hand-made and a mill finished, and be taught to distinguish between the tub-sized and ordinary engine-sized papers. Here, also, the apprentice acquires a knowledge of the size and bindings of business books which will stand him in good stead afterwards. He would further be trained to a knowledge of the sizes and qualities of envelopes and taught how to parcel and keep stock. If the young stationer intends starting business himself an additional term of service in a retail business would be advisable. When his apprenticeship is finished the young journeyman would begin with a salary of something like £60 a year, which would be increased as experience was gained and adaptability shown.

Stationery. The term *stationery* is a very wide one, and includes anything from the modest notebook to the magnificent Russia-bound ledger which finds a resting-place on the desks of our great banks and commercial houses; or from the school pen and pencil to the beautifully and expensively-mounted fountain pen. In fact, the articles sold by the stationer are so many and varied that in these days of specialising various and separate businesses have been evolved. Thus we have law stationers, scholastic stationers, grocers' stationers, and commercial stationers, together with artists' stationers, etc. As the bulk of the business effected by these firms—"bagmen" they are called—is the result of canvassing, it follows that the choice of a site for shop, office, or warehouse is not of paramount importance; nor need the stock be heavy—business to a large extent being done on commission. To keep any of these businesses going, travellers require to be continually on the road. Prices as a rule are closely cut, and competition is keen.

The General Stationer. The man known as the commercial and general stationer conducts his business on slightly different lines, and is to a large extent dependent on the position and appearance of his business premises. It would be well, therefore, to select a shop in a good business thoroughfare; and the shops of first class stationers are usually found in the best parts of all towns and cities. Generally, it is an old business which has come into the market that is acquired—as new businesses either in this line or that of its intimate associate, bookselling, are by no means numerous.

As the beginner would require to provide for mostly all, or rather more than, the departments enumerated above, a sum of £500 to £600 at least would be required fairly to start him in business. If he is a total stranger to the place it might be well for him to allow himself to be guided to some extent by the representative of some good wholesale house who has a knowledge of the requirements of the district. Of course, we say "to some extent," as while it is well to cultivate mutual trust and good relations between buyer and seller, it is a mistake to be too confiding. It may, however, be taken for granted that the representatives of first-class houses —and we are speaking only of such—do not like to see the parcel they sold still resting on the shelves when calling for repeat orders. It would be well also to continue the services of former assistants, who would not only advise as to the wants of the district, but know the former customers and how to deal with their various idiosyncrasies. A sum of money is usually paid for "goodwill," but if the incomer takes over the whole stock at a valuation this should not be large, as he is sinking a good deal of money in goods which it will be difficult to realise.

Profits. The beginner will be told that he will make a profit of from 25 to 30 per ecnt. on the "turnover," and he enters on his new business with rose-coloured dreams of quickly amassing a fortune. He will not be long in business, however, before he finds out that he has got to modify his ideas on that score very considerably, and he will have to be content with something a good deal less than half the lowest sum named. If he is ambitious of doing a big business and goes in for estimating, he will be fortunate—if he does the work honestly, and we presume he will—if he lifts the order with a margin which will leave him a clear profit on the transaction. Here, as in every other business, it is experience that tells.

Some articles in the stationery trade have for some time been so keenly cut by certain traders that they could only be handled at a loss in any attempt at competition. This led recently to the formation of what is called a Proprietary Articles Protection Association, composed of stationers, wholesalers, and manufacturers, under which an arrangement has been come to whereby certain specified articles supplied by the members of the association shall not be sold below a given price, thus allowing a fair working margin of profit to the retailer who handles the articles.

Shop Arrangement. Goods should be arranged methodically; octavos of foolscaps, posts, large posts, and mediums by themselves; quartos of the various sizes by themselves. Business books should be similarly treated. A few glass cases are a decided advantage, and add to the appearance of the premises. In these, the finer bindings and "West-end books," and a few of the more expensive inkstands and stationery cases can be shown. Notepaper and business papers should also be arranged according to quality and size. The various papeteries and mourning stationery should have their own place. In fact, the stock should be departmented—those articles most in demand nearest to hand, and everything arranged so that the shopkeeper may be able to find a given article even in the dark. The employer should insist on each department being kept tidy—with someone responsible for it, and should on no account tolerate broken parcels. As most notepaper and envelopes may now be had boxed, it is not difficult to follow these directions.

All goods coming in should be immediately unpacked, checked with invoice, and carefully marked with cost price in private mark and selling prices in plain figures. Of course, it is a matter of no moment

whether the selling price should be marked in private or plain figures, but most buyers prefer to be able to see for themselves the price of the article they are purchasing. The goods should be carefully assorted in the stock-room and the front shop replenished when necessary, care always being taken that those goods which are in daily demand shall not be allowed to run out. It is always good policy to see that one parcel of any given article shall always be left in the stock-room.

The Windows. The windows ought always to be clean and attractive, and changed often. A good idea is every now and then to have what is called a "one-article window." This, for instance, might take the form of an effective display of papeterie in various sizes, with the stationer's own name and address printed on them. These should always be of good material and extra value. As he has a permanent advertisement in the boxes he should be content with a very small margin of profit. If the contents of the papeterie please his customers the chances are that he will not only have repeat orders, but have the satisfaction of selling other goods as well. Make a point of discarding cheap and nasty stuff and of supplying only the best value possible. This is the best way to keep on good relations with customers and to build up a business on a sound and solid basis. Allow your name to appear on nothing that is not really first class. The advertisement is permanent whether for good or evil.

On another occasion the stationer may make a show of business books. If, for instance, he has secured a specially good order for a set of business books from some large firm, he may put them in the window for a day or two, taking care that the titles of the books and the name of the customer for whom the order is being executed are not exposed to the public.

Fountain Pens and Typewriters. Then, again, in fountain pens there is a large and ever increasing business being done. These, as a rule, afford a fair margin of profit, and the best of them come under the rules of the Proprietary Articles Association. While they should always be well forward both in the window and on the counter of the up-to-date stationer, a "one-article" window of them might occasionally be made. Of course, a hundred pounds will not go far in this way; but it will pay to make now and again a good display of them. Without offensive pushing they can be turned into a good source of revenue. It is a good plan always to have one or more in your own pocket which you can allow your customer to try—one that you are using daily, and therefore ready to write the moment it touches paper. If the pen you are in the habit of using does not suit your customer, another from stock can easily be substituted.

The typewriter is usually handled by specialists; but there is no reason why the stationer should not now and again dispose of a machine. There is money in the business. He has a typewriter, as a rule, for his own use. Why not get an agency and keep beside him a good supply of attractive catalogues which he might judiciously use to good purpose? At any rate, there is no reason why the papers, ribbons, carbons, etc., necessary for the manipulation of the typewriter should not be supplied by the stationer. A small stock of these articles can easily be got. They are usually supplied in neat, cardboard boxes, and can, therefore, be tidily kept and easily handled. If a trade is done with law or commercial houses, a book of samples might be taken round and shown, and prices quoted—in fact, neat booklets of samples can be obtained for distribution. These can be stamped, or, what is better, have printed the stationer's name and address. This will lead to increased business. Do not be above going out and pushing your business.

Letter-presses are sold only occasionally, and a large stock of them need not be kept. One or two should be stocked, however, to show styles and to be ready in case of emergency. Orders can be taken from makers' lists.

Die-stamping. Die-stamping forms a large and fairly profitable part of the stationer's business, and it is one which he will do well to cultivate. A good many wholesale houses now issue books of samples, showing qualities of paper and styles of stamping both in "plain" and "relief." Some enterprising firms even go the length of cutting the die free—charging only for the stamping—trusting to recoup themselves for their initial outlay by repeat orders. As there is something attractive and in decided good taste about a neatly stamped note heading, most customers—who would never think of going to the expense of getting a die cut—for the extra charge of, say, a shilling, would be glad to place an order for five quires of notepaper and 100 envelopes. Then, as this trade develops, the stationer will naturally find that he can do with a much smaller stock of notepaper and envelopes. This will liberate a certain amount of capital and allow it to be otherwise employed. Of course, this question opens up a wide field of enterprise which can easily be exploited by the stationer who is alive and knows his business. For instance, there is the interesting subject of wedding stationery, including invitation and complimentary cards; at-home, with menu and guest cards; dinner, dance, and visiting cards; and the perennial, and ever increasing trade in Christmas cards. Show cards—tastefully and artistically arranged—of these can and ought to be exhibited, and the makers' books kept handy for reference, or to bring under the notice of likely customers. Business printing and lithography may be manipulated in the same way by arrangement with lithographers and printers who work for the trade.

Wholesale Houses. A word as to wholesale houses. While there is truth in the saying that it is not good policy to keep all your eggs in one basket—and a comparison of prices is good for all concerned—at the same time, if you have confidence in your wholesaler, and know that he is doing his best for you, you will do well not to multiply accounts. You will not be long in business before you find out that one firm is best for paper; another makes a special feature of envelopes; while a third does business books at a price which the others cannot touch. You ought, above all things, to exercise the greatest caution in taking up "specialities" shown by entire strangers who exhibit an undue anxiety to do you a special favour by making you "sole agent" in the district for their wares, on condition, of course, that you place a good order for a stock of the article. If you do, you may find that others have also been made "sole agents," and that more than one stationer has been landed with articles of which he will find some little difficulty in getting rid. As a rule, you can get "the latest novelty" from one or other of the wholesale houses with whom you deal.

Continued

EXAMPLES IN THE ELLIPSE

Ellipses not Struck from the Same Centres. Ellipse Tapering to Circle. Objects with Varying Slant. Conical Tube. Seams and Joints. Rivets and Riveted Joints

continued from page 5166

By JOSEPH G. HORNER

To Mark Out in Four Pieces a Tapering Elliptical Article. In this the taper at ends and sides are unequal. Fig. **136** shows the depth, and **137** the plan. In **137** there are two ellipses concentric with each other, but marked from separate sets of centres. Fig. **139** is a pattern of the side, obtained as follows: From the point 3 [**137**], which is the centre from which the larger curve of the outer ellipse is struck, draw the vertical line 3 4, and continue the large curve round to meet it at 4. Draw the horizontal line 4 5 from 4, making its length the same as the vertical depth of the article 1 2 [**136**]. From the point 5 draw the line 5 6 at right angles to 5 4, the distance from 5 to 6 being the distance between the sides of the outer and inner ellipses at 1 2 [**137**]. From the point 6 thus obtained draw a line passing through 4 to 7, where it meets the centre line 1 8. The distance from 4 to 7 will be the radius of the outer curve *a*8*a* [**139**], the centre of which is located at 9. The inner radius of the side is obtained in the same manner as the outer, by projecting the vertical line 10 4′ [**137**] from the centre 10, from which the curve is struck, until it intersects a continuation of the curve itself at 4′. The depth of the article is again marked from it at right angles, giving the line 4′ 5′; and again at right angles from the end 5′ of this line the distance 5′6′ is set off, representing the distance 1 2 [**137**] between the sides of the ellipses in plan. Through the points 6′ and 4′ thus obtained a line is projected to 11 on the centre line 1 8. The distance from 6′ to 4′, or 6 to 4, is set off from 8 to 12 [**139**], giving the width of the segment. Then with the distance 4′ 11 as radius the inner curve [**139**] is struck through 12, its centre being at 13. The length of this segment comes halfway between the centre lines of the two ellipses at the point 14 [**137**], the distance 1 14 being taken from and set off on each side of the centre line at 8*a*, 8*a* [**139**]. From the length of curve thus obtained radial lines are drawn to the point 13 on the centre line, and the marking out of the segment for the sides of the article is finished.

The end piece [**138**] is struck in a similar manner from the ends of the ellipse. The horizontal line 15*b* [**137**] is projected from the centre 15, from which the end curve of the inner ellipse is struck, until it meets the dotted continuation of the end curve at *b*. The line *bc* is drawn at right angles from *b* 15, its length, *bc*, representing the depth of the article 1 2 [**136**]. A line at right angles therewith from *c* to *d* represents the distance between the inner and outer end curves of the ellipse, 16 to 17 [**137**]. A line is drawn through the points *db* to cut the centre line at 18. The distance from 18 to *b* is the radius of the inner curve [**138**], struck from the centre 13. The width of the segment is taken from *d* to *b* [**137**], and set off from 11 to 19 [**138**]. The radius of the outer curve at 19 [**138**] is obtained by projecting the horizontal line [**137**] from 18, the centre from which the outer curve is struck, to *b*′, where it meets the dotted continuation of the curve. The perpendicular from *b*′ to *c*′ is the same length as 1 2, on **136**, and the horizontal from *c*′ to *d*′ is the same length as the distance between the ellipses 16 to 17 [**137**]. A line drawn through *d′b′* gives the point where it cuts the centre line, and from that point to *b*′ is the radius with which the outer curve of **138** is struck. Its centre is at 20, which is fixed by the width of the segment, obtained either from *db* or *b′d′* [**137**]. The length of the segment is measured from 17 to 14 [**137**], and set off on each side of 19 in **138**, 19*e*, 19*e*.

To Describe the Pattern for a Canister Top. This tapers from an ellipse to a circle. Fig. **140** is the elevation, **141** the plan, and **142** the development of the pattern in one piece. Draw on the plan a diagonal line 3 2 between the points where the end and side curves intersect. Then in **143** draw a centre line 1 0, and two transverse lines at right angles therewith at the same distance apart as those representing the depth of the article 1 1 [**140**]. Transfer the length 2 3 from **141** to the line 2 3 [**143**], and also the diameter of the hole 4 5 to the line 4 5 [**143**]. Project lines through 2 4 and 3 5 to cut the centre line at *o*. With *o*2, or *o*3, as radius strike the curve 2 3 [**142**] from centre *o*. Returning to the plan [**141**] draw a perpendicular from 6, which is the centre from which the side of the ellipse is struck, and continue the curve of the side round to meet it at 7. Draw a line at right angles with 6 7 from 7 to 8, of the same length as the depth of the article 1 1 [**140**]. Draw another line at right angles with 7 8, from 8 to 9, making its length the same as the width of the side, 4 to 10 [**141**]. Then produce a line from 9 through 7 to cut the transverse centre line at 11. With 11 7 as radius strike the arc 2 3 [**144**], and draw the perpendicular *o*1 through the centre *o*. Divide half the length of the side, 3 to 23 [**141**], and mark off the same number of divisions each side of the centre 1 on the curve 2 3 of **144**. Draw also the radial lines 3*o*, 2*o*, and the chord 2 3.

Next, from 12 on the plan [**141**], which is the centre from which the end curve is struck, project a horizontal line to meet an extension of the curve at 13. Draw a line at right angles with 12 13, from 13 to 14, corresponding in length with the depth 1 1 [**140**], and then another line at right angles with this, from 14 to 15, corresponding in length with the width of the end, 1 to 17 [**141**]. Project a line from 15 through 13 to cut the centre line at 16. With radius 16 13,

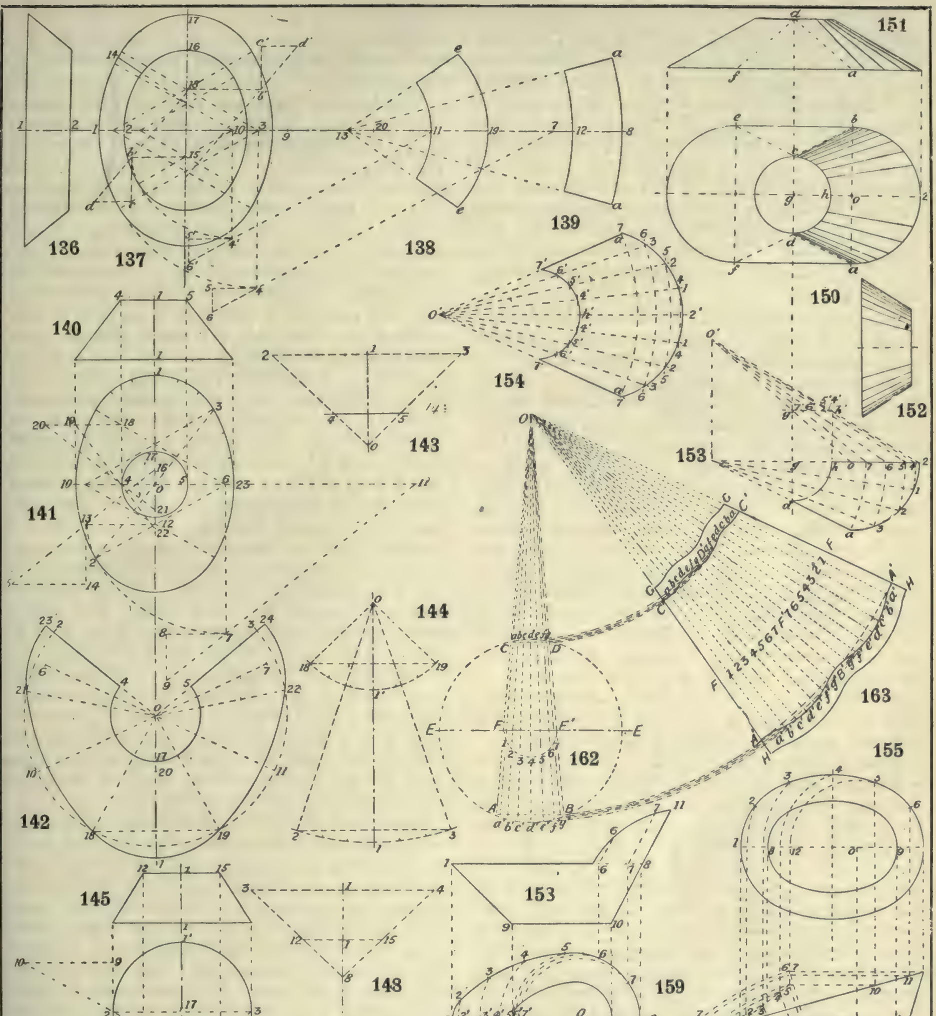
and from o [**144**] as centre, strike the arc 18 19. Measure the end curve [**141**] from 1 to 3, and transfer its dimension to each side of the centre 1′ on the curve 18 19 [**144**]. Draw radial lines from 18 and 19 to the centre o, and also the chord 18 19. Transfer the length of the latter to the chord 18 19 [**142**], cutting the boundary circle 2 3 at 18 19. With the radius o18, from **144**, strike the arc 18 to 19 [**142**], its centre being on the centre line at 20, and its ends coinciding with the intersections of chord and circle at the points 18, 19. Then take the chord distance from 2 to 3 [**144**] and transfer it from 18 to 21, and from 19 to 22, intersecting the boundary circle. Bisect these lengths at 10 and 11, and project lines from all these points to the centre o, extending the lines from 10 and 11, through o, to the points 7 and 6 beyond respectively. The points 6 and 7 are the centres from which the curves 21 18 and 22 19 are struck, the radius being taken from o to 1 [**144**]. Next measure the length of the boundary circle from 18, or from 19, to the centre line 1′ [**144**], and transfer the same from 21 to 2, and also from 22 to 3 [**142**], and draw the radial lines 2o and 3o. Then with the radius 20 1 [**142**], from which the curve at the base is struck, describe the arcs from 21 to 23, and from 22 to 24, the centre in each case being on the radial line which marks the end of the pattern. This finishes the development of the exterior of the pattern and leaves the circular hole to be marked out.

Draw on the plan [**141**] a vertical line from 4 to 18, corresponding in length with the vertical depth of the article, 1 to 1 [**140**]. From 18 draw a line at right angles with 18 4, through 19 to 20, the distance from 18 to 19 corresponding with the dimensions from the edge of the circle to the ellipse, or 4 to 10, and the distance from 18 to 20 corresponding with a similar measurement lengthwise, or 17 to 1. From 19 and 20 draw lines through 4 to cut the centre line at 22 and 21 respectively. Take the length from 20 to 4, which is the slant of the end, and mark it off on the radial lines of **142**, from 23 to 4, 1 to 17, and 24 to 5, thus obtaining the points 4, 5, 17, through which the curve for the hole is struck. Then with 4 21 from **141** as radius, describe arcs through these points, the one which cuts 17 being struck from the centre line o1, and finishing where it cuts the radials o18 and o19 ; and the arcs from 4 and 5 being half the length, struck from the lines o4 and o5, and ending at the radials 21 and 22. The centres from which these three arcs are struck are too close to the common centre o to be distinguished by separate numbers. The connection between these arcs is now completed by taking the radius 4 22 from **141**, and joining them with arcs of this radius struck from centres on the lines 6 11 and 7 10 [**142**].

To Describe a Tapering Neck with Parallel Sides. This has semicircular ends, and a circular hole in the top. Fig. **145** is the elevation and **146** the plan of the article. Fig. **147** is the development in one piece, with the joint at one end. Through the centres of **145**, **146**, and **147**, a perpendicular line 1 1 is drawn. In the plan [**146**] there are three horizontal lines, 6 7 being central, while 2 3 and 4 5 pass through the centres from which the end semicircles are struck. To proceed with the development, extend the line of one side, in **146**, to the point 9, the distance from 2 to 9 being the same as the vertical height 1 1 [**145**] of the article. Draw a line at right angles with 2 9, from 9 to 10, the distance between 9 and 10 being taken from o at the edge of the hole to 1′ at the semicircular end, thus representing, in plan, the taper from hole to end. Draw a line from 10 through 2 cutting the centre line 1 1 at 11. From the point 12 on the circle representing the hole draw a line to 13, the distance between 12 and 13 representing the depth of the article 1 1 [**145**]. Take the distance from o to 1′ as before and transfer it to the horizontal line 13 to 14. Then draw a line from 14 through 12 to 11, where the centre line is cut by it. In this case the diagonals both from 14 and from 10 happen to meet at 11, but with different proportions they would cut the centre line at different points. Next, in **148**, draw horizontal lines 3 4 and 12 15, at distances apart, 1 1, corresponding with the depth of the article, 1 to 1 [**145**]. Draw the centre line 1 8 [**148**] at right angles with these lines, and on the upper horizontal line mark off on each side the distances 1 3 and 1 4, corresponding with 1 3 and 1 4 on the diagonal line in **146**. On the lower horizontal line [**148**] mark off the diameter of the hole 12 15, similarly numbered on the other views. Through these four points, 3, 12, and 4, 15, draw the diagonal lines cutting the centre at 8, as shown in **148**. With 8 3 or 8 4 as radius, strike the large boundary curve 3 4 20 from the centre 8 [**147**].

Now, with radius 1 12 [**146**] strike the curve 4′ 1′ 5′ from centre o [**149**]. By stepping round with dividers, make the length of this curve similar to the length of curve in one of the semicircular ends in **146**, and draw the chord 4′ 5′ [**149**]. Draw a chord of similar length across the lower part of the boundary curve in **147**, giving the points 17 and 18. From these points, with dividers set to the radius o4′ or o5′ [**149**] mark off the point o' on the centre line of **147**. With o' as centre, strike the curve 17 1 18, corresponding with the curve in **149**. Next take the length of the side, 3 5 in **146**, and mark it off from 17 to 16, and from 18 to 19, in **147**, intersecting the boundary curve. Draw lines from these points to the centre 8. Then, from the centre 8 strike a curve through the point o, giving the points a and b whence the radial lines to 21 and 22 are drawn. The points a and b are centres from which the curves 22 16 and 21 19 are struck, their radius being the same as the curve struck from o' in the lower part of the view. The pattern of the outside is now completed by connecting the curves by the tangential lines 16 17 and 18 19.

For the development of the round hole in the top, bisect the line 16 17 at c, and 18 19 at d [**147**] and produce them to r and s respectively. Take the length 14 to 12 [**146**] and set it off in



EXAMPLES IN THE ELLIPSE

136–139. An ellipse with unequal taper **140–144.** Elliptical figure tapering to a circle **145–149.** An object the ends of which form conic frusta **150–154.** Another method of development **155–157.** An elliptical figure with unequal slant **158–160.** Development of an oval bath **161–163.** Development of plate for conical tube

147 from 1 to g, 22 to h, and 21 to j. Take also the distance 11 to 12 in **146**, and in **147** set it off respectively from g to k, h to l, and j to m; k, l, and m are centres whence are struck the curves hn, jo, and pgq. The radius of the connecting portions is obtained by drawing in **146** the diagonal line between points representing the depth of the article and the slant of the side, and prolonging this line to the point 17, the distance from 17 to 12 being the radius required. The centres in **147** are located at s and r on the prolongation of the bisecting lines c and d.

Another Method. Problems of this and allied kinds may be approached, and rendered more obvious perhaps, by regarding them directly from the point of view of the cone. Thus, in **150**, **151**, **152** the shading introduced shows that the ends of the articles must be portions of oblique cones, the construction of which has been explained on page 4737. The point is, that the base can be divided round into any number of equal parts, and lengths taken from those divisions to the apex, through which points the required curve can be drawn, and the plane of truncation can be treated similarly.

Looking now at **150** and **151**, we can regard the article (irrespective of the question of actual jointing up) as formed of segments only of conic frusta, meaning by that that the cylindrical shapes are incomplete. They terminate at a, b, c, d. They are connected with plane triangular pieces a, d, f, and b, c, e. Fig. **153** shows the method of development.

Draw a horizontal line $1'$ $2'$. Set off a centre o from 2 in **150**, and with the same radius describe the quadrant $2'a$, equal in length to $2a$ in **150**. Step round on it any convenient number of chord lengths, $2'$, 1, 2, 3, a. Set off on the line $1'2'$ the distances $2'g$ and $2'h$, corresponding respectively with the centre of the round hole and its edge, in **150**, and raise perpendiculars therefrom. Draw a horizontal $g'h'$, corresponding with the plane of the top of the article. Draw lines through $2'h'$ and through og' prolonged, to intersect at the centre o', which locates the apex of the oblique cone, and drop the perpendicular $o'1'$. From $1'$ describe arcs from 1, 2, 3, a, to intersect the line $1'2'$ in 4, 5, 6, 7, respectively. Connect these points with the apex o', cutting the plane $g'h'$ at $4'5'6'7'$. Next take the slant length $o'2'$ [**153**], and set it off from o' to $2'$ [**154**]. Similarly, take successive radii, $o'4$, $o'5$, $o'6$, $o'7$, and set them off in **154** as shown by corresponding references. Take the successive equal divisions, $2'1$, 1 2, 2 3, $3a$, in **153**, and step them round from $2'$ to 1, 2, 3, a, in **154**, and draw lines through the points of intersection to the centre o'. A curve drawn through these points of intersection $2'$, 1, 2, 3, a, repeated on the other side of the centre line will give the development of the curved base of the truncated cone. For the round hole in the top, complete **154** thus:

Take successive radii from o' [**153**] measuring thence to h', $4'$, $5'$, $6'$, $7'$, and transfer to **154**, cutting the radial lines at h', $4'$, $5'$, $6'$, $7'$, repeated on each side of the centre line. These will form the points of intersection through which the curve is drawn.

To Mark Pattern for an Elliptical Object with Angles Constantly Changing. Fig. **155** is the plan of the object, and **156** the elevation. In plan, the taper appears equal all round, but in elevation the angle is seen to vary, because the back is higher than the front. In **156**, project the lines 7 9 and 1 8, till they meet at the common centre o. From o carry a perpendicular up to o on the centre line 1 7 of **155**. Divide one half of the outer ellipse into any number of parts, as 1, 2, 3, 4, 5, 6, 7. With o on the line 1 7 as a centre, strike arcs from 2, 3, 4, 5, to cut the line 1 7. An arc from 6 [**155**] would coincide with the one from 5, and also one from 7, and the extreme points 1, 7, coincide with the points 1 and 7 on the elevation [**156**]. Drop a perpendicular direct from 5 on the ellipse to 10 on the line 1 7 of **156**, and another from the point 12, where the arc from 5 on the ellipse cuts the centre line 1 7, stopping the latter perpendicular at 5 on **156**, which is the point where a horizontal from the intersection 10 of the first perpendicular and the sloping line 1 7 occurs. From the point 5 draw a sloping line to 1. Draw also a horizontal from 7 to 7, and another from 6 to 11, which is the point on the line 1 7 where a perpendicular from 6 [**156**] cuts it. We have now points 1, 2, 3, 4, 5, 6, 7, on **156**. From each of these draw a radial line to the centre o, and then with o as a centre describe curves of indefinite length from each of these points on the upper part of **156**, and also from each of the radial intersections on the line 8 9 of **156**.

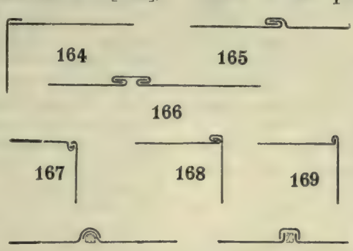
Draw now the line $7o$, of **157**, clear of the lines of the elevation, and then with dividers set to the divisions on the ellipse [**155**], step from 7 [**157**] to 6, and so on till the point 1 is reached, beginning on the outer circle 7, and stepping across from one circle to the next till, at the point 1, the inner circle of the same number is reached. Through these intersections the outer line of the pattern is drawn. The inner line is traced through the intersections of radial lines with the inner set of curves, stepping as before from one circle to the next, the widest part of the pattern being at the end $7o$, and the narrowest at the end $1o$. This gives the pattern for one half of the object.

To Strike in One Piece the Pattern for an Oval Hip-bath. Fig. **158** is the side elevation, and **159** the plan. The shape of the inner oval is decided by the position of the points 5 and 10 on the centre line, and need not be drawn. In **160** draw the two horizontal lines 1 8 and 9 10, at the same distance apart as the top and bottom lines similarly numbered in **158**. Project perpendiculars from 1, 5, 10, 8, on the centre line of **159**, to the upper line 1 8 [**160**], continuing those from 5 and 10 to the lower line 9 10. Draw lines from 8 and 1 through 10 and $1'$ [**160**] to meet at the centre o. Project a perpendicular up from o to o on the centre line of **159**. Then divide the upper half of the outer oval [**159**] into any convenient number of parts, as 1, 2, 3,

etc., and from the centre o on the same figure describe arcs from each of these points to cut the centre line 1 8 at 2′, 3′, etc. From these points, similarly numbered on the line 1 8 [**160**], continue lines converging to the centre o and cutting the line 9 10 in 1′, 2′, 3′, etc.

With o as a centre now describe curves of indefinite length from each of the intersections, both on the line 1 8, and the line 9 10, as shown in **160**. Then, with the dividers set to the divisions round the oval in **159**, start from 1 at the end of the line 1 8 [**160**], and step off round the curves the same number of divisions, crossing the curve 1 to 2, 2 to 3, and so on at each step until the centre line is reached, where the number of steps has amounted to the same as those round half the oval in **159**. Then proceed with a similar number to complete the other half, but working across the curves in the opposite way, so that the final step occurs again on the outer circle at 1 on the lower right-hand side of **160**. From each of these points of intersection draw radial lines to the centre o, which will give the correct points of intersection on the inner set of circles from the line 9 10. Through these intersections trace the outer and inner lines of the pattern.

To obtain the shape of the back, draw perpendiculars from 6′ and 7′ [**159**] to the line 1 8 [**158**], and thence continue them parallel with the back, 10 11, till they cut the curve (which has previously been decided on) at 6 and 7. Take the distance 8 to 11 and mark off the same from 8 to 11 at the back of the pattern in **160**. Take also in turn from **158** the distances 6 to 6′ and 7 to 7′ from the curve to where they cut the horizontal, and mark off these lengths from the points similarly numbered on each side of the centre 8 on the outer curve of the pattern. Through these points trace the curve 6′ 7′ 11.

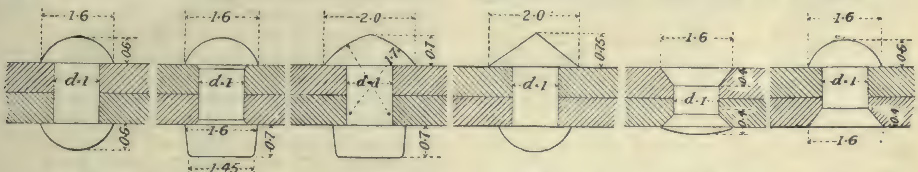


164 165 166 167 168 169 170 171

VARIOUS SEAMS AND ROLLED JOINTS

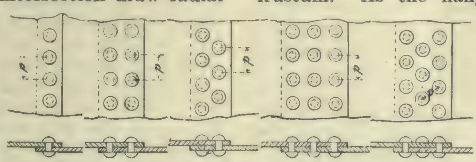
Conical Tube. Fig. **161** A is a common fitting, the well-known conical, or "Galloway" circulating tube. It is fitted both into the furnace flues of horizontal boilers, and the fireboxes of vertical types. Fig. **161** shows it as fitted in a parallel flue. The tube A is thrust through the larger hole of the furnace B, which is large enough to allow the flange C to clear. The flanges C and D are secured by riveting.

As the tube is of sensible thickness—from $\frac{1}{4}$ in. to $\frac{3}{8}$ in.—the dimensions correspond with the external diameters after bending and welding. These diameters are AB and CD [**162**], and the diameter of the furnace flue is indicated by the circle EE. Lines are projected through AC and BD to a point o, where they meet, which is the apex of the cone of which the water tube is a frustum. As the flanges fit a cylinder, the regular curves of some previous developments are unsuitable. The varying curves required are obtained on lines of equal division stepped round the conical body as at FF′. A half circle is divided round F, 1, 2, 3, 4, 5, 6, 7, F′. Draw lines through these points from o to cut the circle of the furnace flue in a, b, c, d, e, f, g, on the smaller end, and at a', b', c', d', e', f', g', at the larger end. From the points where these lines of division on the cone cut the circle of the furnace EE draw radii from o as a centre to **163**, which shows the development of the plate.



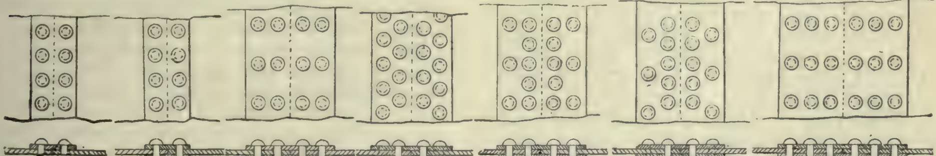
172 173 174 175 176 177

PROPORTIONS OF RIVETS



178 179 180 181 182

FORMS OF LAP-RIVETED JOINTS



183 184 185 186 187 188 189

FORMS OF BUTT-RIVETED JOINTS

In **163** draw a centre line oB', and to right and left of it set off the length $B'A'$ equal in length to the circumference of the large diameter AB of the tube in **162**, and divide the length into twice the number of equal parts of the half circle in **162**, $A'\ a'\ b'\ c'\ d'\ e'\ f'\ g'\ B'\ g'\ f'\ e'\ d'\ c'\ b'\ a'\ A'$ [**163**]. Draw lines thence to the apex o. At the points where these radial lines intersect the curves drawn from **162** draw the outlines of the plate as indicated by the similar references. The middle plane FF might be divided instead of the end, as indicated. Beyond these outlines add sufficient for flanging—namely, the lines GG, HH.

Joints. A very condensed account of joints must now conclude this course.

Joints in sheet and plated work are made by soldering, brazing, welding, lapping, or rolling simply, and by riveting, and bolting.

With regard to the additions made, these are generally of the character shown in **163**—that of supplementary width added to the edge or edges of the developed outline. But in many cases the joint has to be made somewhere in the body of the development.

Soldering and Brazing. The joints for union by these methods are of various kinds. The commonest is the lap. Edges are sometimes thinned down to a *feather edge* before lapping in order to maintain an even thickness. The thinnest sheets are generally left untouched, which leaves a slight thickness or angle to be occupied by solder and assist the holding of the solder in the joint faces. Abutting joints are not used much for soft soldering, though rather more frequently for brazing. But the small area of the parts in contact prevents making a strong job.

A good many joints at right angles are made by abutting joints, because an angle of solder can be run down the internal angle as well as between the faces. But all strong joints must have considerable surfaces for the soldering material to adhere to. An example of this kind was illustrated in the cramped joints of the coppersmith [page 3884], which are made in joints in one plane, in curves, and at right and other angles. In work in tin, zinc, and lead other kinds of lap joints are common, such as lapping and rolling.

Fig. **164** shows a plain angular joint in which the edge of one sheet is bent over to cover the edge of the sheet adjacent, and soldered. Figs. **165** and **166**, show two forms of lap joints made watertight without soldering, the seams being closed by hammering. Fig. **167** shows an angle joint that must be soldered, otherwise it could be pulled apart. Figs. **168** and **169** are other forms which may be soldered or not. Figs. **170** and **171** are roll joints for lead and zinc respectively, which need not be soldered.

Welding. Welding has been described under Smiths' Work [see page 2988]. It is a process employed for pieces of sensible thickness, as bars, rods, sections, and plates, but not for thin sheets.

Riveting. To discuss all the points in connection with riveted joints would cover a very wide field. We must be content to show the forms of rivets and the more important types of joints.

The commonest type of rivet used by engineers is the *cup-head*, or spherical head rivet [172]. In this both head and tail are alike. In **173** the tail is still of the cup section, but the head is of the *pan* shape, which is stronger. In **174** the head is of pan shape, but the section of the tail includes two curves, *conoidal* head; **175** is the conical tail formed by hammering only. In each of these the head and tail stand beyond the faces of the plates. When this is objectionable *countersunk* rivets are used [**176**]. Sometimes one end only is countersunk, as in **177**. Proportions vary slightly, but those given in the figures show average practice. In each case the unit is the diameter, d, of the stem, or *shank* of the rivet.

The numerous forms in which riveted joints occur are not determined arbitrarily. Joints in the same plane are as follows: *Lap* joints *single riveted* [**178**]. These are the weakest forms. A stronger joint is made by *double* riveting, and this may be of *chain* type [**179**], or *zig-zag* [**180**]. In some cases *treble* riveting is used, either of chain type [**181**] or zig-zag [**182**]. The objection to all these is that the plates are not in the same plane. The method is suitable for uniting belts of plating in cylindrical boilers, *circular* seams, but not for longitudinal seams, which would develop grooving. Hence the superiority of the *butt* joints. In these, plates which abut in the same plane are riveted through a covering strip, or strips, *butt strips*, or *straps*. *Single butt straps* [**183**] are used, or *double butt straps* [**184** to **189**]. A strap on each side makes a better job than a strap on one side only. As in lap joints, the rivets are arranged in single lines, *single riveting* [**183, 184**], in two lines, *double* riveting [**185** to **188**], or in three lines *treble* [**189**], and also as chain and zigzag riveting as illustrated.

Close and Open Riveting. The whole of the proportioning of riveted joints is a compromise between the strength of the plate left between the rivet holes, and between the edges of the holes, and the edges of the plates for butt straps, and between the tightness of the joint to resist steam or water pressure. To lessen the loss of strength consequent on making the holes for the rivets, the spacing is increased. But for tightness of jointing the spacing should be lessened. This explains the zig-zag riveting, in which provision is made for leaving the plates with the maximum strength possible, and close joints, and the reason for the close and open riveting in **187** and **188**. This also explains why the spacing for steam boilers and vessels subject to hydraulic pressure always is closer than that for bridge and girder work.

The pitch of rivets, p, in the figures is the distance between adjacent centres. In no case should this be less than enough to leave a space equal to the diameter of the rivet between adjacent holes, and it is generally more. The same rule holds with regard to the width of metal left between the edge of a hole and adjacent edge of the plate, or the covering strap. In zig-zag riveting the diagonal dimensions must fulfil the same conditions, and not the spacing between the rows.

Drawing for Sheet-metal Workers *concluded; followed by* Drawing for Architects

THE TRANSMISSION OF POWER

Shafting, Pulleys and Belting. Rope Driving. Bevel and Cog-wheel Driving. Transmission of Power by Hydraulic and Pneumatic Agencies

Continued from page 5128

By F. L. RAWSON

NOT only is it almost invariably the case that power has to be transmitted from the place where it is produced to some other place where it is utilised, even within the confines of a single factory or works, but it is becoming more and more usual to concentrate the generation of power at central points and thence to distribute it to consumers of all classes within a radius which may vary between a few yards and many miles. It is evident, therefore, that means must be provided for transmitting the power, to suit the very diverse conditions met with. The principal methods may be classed under the following heads: mechanical (shafting and gearing); electrical; pneumatic; and hydraulic. Steam and gas are also used, though they come under a slightly different category. The former can be employed only over comparatively short distances, and is so wasteful that it may be set aside at once; but the latter is excelled only by electricity in point of the range covered.

Shafting. Shafting constitutes the most elementary means of power transmission, sometimes being the only means, as where the engine is coupled direct to the driven machine by a piece of shafting, short or long. Locomotives, steamships, pumping engines, steam-dynamos, ventilating fans, and many other kinds of machinery are almost invariably constructed in this way. and often the counter-shafting in large workshops is driven directly from the engine. Shafting, however, can be economically employed only over distances not exceeding about 300 ft., owing to the friction, torsion, and other disadvantages attending its use. Except in very short lengths, it must be perfectly straight, and where the power is to be carried round a corner, bevel gearing or belts must be employed, with the accompanying increased cost of installation and maintenance, and loss of power. On the other hand, it is rarely economical to drive every individual machine in a factory or workshop by independent means, and therefore short lengths of shafting, each driven by a separate motor (nowadays, almost always an electric motor) and driving a number of machines, are the general rule. Mild steel shafts are used, running at speeds usually between 100 and 300 revolutions per minute; the principal dimensions, etc., are obtained from formulæ such as the following:

Horse-power transmitted:

$$HP = \frac{1}{70} D^3 N.$$

Diameter of shaft:

$$D = \sqrt[3]{\left(\frac{70 \times HP}{N.}\right)}$$

Space between bearings:

$$S = 5 \sqrt[3]{D^2}.$$

where HP = the horse-power to be transmitted,
N = the number of revolutions per minute,
D = the diameter of the steel shaft in inches,
S = the space between bearings, in feet.

If a wrought-iron shaft is used the diameter must be increased, for the same horse-power, by 15 per cent. The foregoing values apply to mill shafting carrying pulleys for belt driving, etc. For pure transmission of power, without bending stresses, lighter shafting may be used. The loss of power in friction due to shafting depends enormously upon the attention given to the bearings, both in erection and in upkeep, and is seldom less than 25 per cent. of the power applied, often more than 50 per cent.

Belting and Pulleys. The most convenient and usual method of taking power off shafting is by means of leather belts running on pulleys. The pulleys are preferably made in halves, so that they can easily be mounted on the shaft without disturbing the latter, and are usually made of cast or wrought iron, the latter especially when the pulleys are large. Large numbers of wooden pulleys are also used. The faces of the pulleys are slightly rounded, the greatest diameter being in the middle, for use with plain belting, this device keeping the belt in position; but wrought-iron pulleys are often cylindrical, and so are pulleys used with link belting. They are fixed on the shaft with keys, fitting between a flat filed on the shaft and a key-way provided in the boss of the pulley, but split pulleys can be fixed sufficiently tightly, as a rule, by means of the bolts which hold the halves together, without the use of keys. The ratio of the diameters of driving and driven pulleys should not exceed 6 : 1, and the distance between centres should be such that the arc of contact of the belt on the smaller pulley is never less than 150 degrees, greater if possible. Vertical or steeply inclined belts should be avoided.

Theory of Power Transmission by Belting. Leather belting is most commonly used, though cotton belting is also very satisfactory. Single leather belts are about 0·25 in. thick, and the width varies according to the power transmitted. The speed of the belt, which is practically equal to that of the pulley rim, is an important factor, as the higher it is the greater is the power that can be transmitted. A limit is set to this, however, by the action of centrifugal force, which renders it undesirable to employ a speed higher than 5,000 ft. per minute. When the power is greater than can be dealt with by means of a single belt, a double belt is used, about 0·4 in. thick. Still stronger

belts are made up of leather links, laid on edge side by side, and joined together with steel pins, which act as hinges. The power transmitted is proportional to the difference in tension between the two sides of the belt, and the tight side is generally subject to about twice the tension of the slack side. The weakest part of a belt is the joint; allowing for this, the safe working tension in the tight side is 300 lb. per square inch of cross section, and the useful pull transmitted is 150 lb. per square inch, or 37·5 lb. per inch of width of a single belt, and 60 lb. in the case of a double one. The following formulæ apply to single and double leather belts, of 0·25 and 0·4 in. thickness respectively:

Horse-power transmitted by belts:

$$\text{Single: } HP = \frac{3}{10{,}000} \times WDN,$$

$$\text{double: } HP = \frac{4{\cdot}8}{10{,}000} \times WDN,$$

where W = width of belt in inches,
D = diameter of pulley in inches,
N = number of revolutions of the *same* pulley per minute.

The velocity of the belt is given by the formula:

$$V = 0{\cdot}26 \times DN$$

where V = velocity in feet per minute.

Link Belting. The power transmitted by a link belt depends upon its construction, but may be taken as approximately equal to that of a double leather belt. Cotton belts come between single and double leather belts in point of strength. It must be added that different thicknesses can be obtained in each case, and the foregoing formulæ strictly apply only to the average values; differences in the ratios of tensions in the two sides of the belt, in the arc of contact, etc., also enter largely into the determination of the safe load of a belt.

Rope Driving. For heavy drives cotton ropes are frequently preferred to belts. These are generally from 1 in. to 2 in. in diameter, and the pulleys are provided with grooved rims, each rope running in a separate groove. The sides of the grooves are inclined towards one another at an angle of about 45°, so as to grip the rope firmly, without allowing it to touch the bottom of the groove. The working tension is about the same as with leather belts—namely, 300 lb. per square inch (of the circumscribing circle), but the tension in the slack side is less than half that in the tight side, so that the power transmitted per square inch is greater. The usual speed is about 5,000 ft. per minute, and the diameter of the smaller pulley should not be less than 30 times the diameter of the rope. Assuming the ratio of the tensions in the two sides of the rope to be 5 : 1, and the speed in the neighbourhood of 5,000 ft. per minute, and allowing for centrifugal force, the following formula gives the horse-power transmitted by each rope:

$$\text{Horse-power transmitted: } HP = \frac{1}{1000} d^2 DN,$$

where d = diameter of circumscribing circle of rope, in inches,
D = diameter of pulley, in inches,
N = number of revolutions of the *same* pulley per minute.

Thus a single rope may transmit as much as 75-horse power, and by placing 20 ropes side by side, 1,500-horse power may readily be dealt with, a power which would require an unwieldy leather belt if such were used. Ropes are more efficient than belts, but the latter have the advantage that they can be used to transmit power between shafts which are not parallel with one another, and can readily be taken off or moved from one pulley to another; this operation is frequently necessary in the case of the belts used to drive individual machines, the belt resting on an idle or "loose" pulley when the machine is at rest, and being transferred to the working or "fast" pulley when it is desired to use the machine. Hence, although ropes may be employed to drive the shafting in a mill or factory, belts are almost invariably used to take the power off the shafts for the machines.

Power Transmission by Gearing. Where a shaft is required to drive another at a different speed, the two being close together, toothed gearing is often used. In this case each shaft carries a wheel provided with teeth round its circumference, the teeth of one wheel engaging with those of the other and driving them. As the teeth on both wheels are equally spaced, the relative speeds of the two wheels and shafts are in the inverse ratio of the numbers of teeth on the respective wheels, the smaller wheel running faster. The shape of the teeth is carefully designed so that they roll upon one another with the minimum of friction; they are either cast with the wheel, which may be of cast iron or steel, or are cut out of the solid rim when the best results are desired. Gear wheels are almost invariably noisy, however well they are fitted together; sometimes one of the wheels is made of raw hide to diminish the noise, or the teeth are made of helical shape for this purpose. Obviously, gear wheels cannot be used with advantage to transmit power over a distance exceeding a few feet, and in this respect they are inferior to belts and ropes. They are very useful, however, for driving shafts which form an angle with one another, the gear wheels, which are then called *bevel wheels*, being made of conical shape; they can also be used for fairly high speed ratios, and have the advantage of great compactness.

Worm Gears. For excessively high speed ratios, such as 30 : 1, worm gear is often used. This consists of a toothed wheel driven by a "worm," the latter being a single turn of a screw-thread, the pitch of which is equal to that of the teeth of the gear wheel; thus one revolution of the worm causes the wheel to advance one tooth. Owing to the sliding friction between the worm and the teeth, it is absolutely necessary that they shall be thoroughly well lubricated in order to reduce the loss of power, and for this reason worm gear should always be immersed in an oil bath. It is rarely used for transmitting large powers.

Chain Driving. Another positive driving device is the chain and sprocket-wheel, the most common illustration of which is the driving gear of bicycles; but the latter as ordinarily made is

inferior to the Renold "silent" chain, which drives on the flanks of the teeth instead of against the roots, and automatically adapts itself to the teeth as wear takes place.

Friction Gearing. Omitting the teeth from the circumference of gear wheels, and pressing the two smooth wheels together, we obtain friction gearing; this is sometimes used for transmitting small powers, and has the advantage that it is noiseless, and will slip rather than break when overloaded. Preferably the gear consists of a wheel built of paper or leather discs compressed between two plates of iron, working against a cylindrical cast-iron pulley. Unfortunately, considerable pressure is thrown on the bearings by this gear, and oil accidentally dropped on it immediately causes slipping.

All the foregoing methods are available for use in works and machines, and their efficiencies are all of the same order—about 90 per cent.—but in the case of worm and chain gearing as ordinarily used, the efficiency may be much lower; in fact, 90 per cent. is attainable with these gears only under exceptionally favourable conditions.

Wire-rope Driving. When power is to be transmitted to a distance exceeding the limits of a factory, different methods must be used. The one which most nearly resembles those discussed above is that of driving by means of wire ropes, consisting of steel wires stranded together, spliced to form a continuous loop, as in cotton rope gearing, and passing over the driving and driven pulleys, each of which usually has only one groove. The distance between the driving and driven pulleys should not exceed 500 ft. If greater distances are to be covered, successive relays must be used, the first driven pulley becoming the driver for the second rope, and so on; in this case the intermediate pulleys have two grooves each. Sometimes guide pulleys are used to support the rope at intervals between the main pulleys. By means of ropes 1 in. in diameter, it is possible to transmit 300-horse power a distance of half a mile with an efficiency of nearly 90 per cent., the relays being five in number, and the rope running at 4,000 ft. per minute.

Electrical Power. When distances exceed 300 ft., however, it is far better to adopt one of the methods mentioned on a previous page —namely, electrical, pneumatic, or hydraulic transmission. Of these, electrical transmission is discussed in the course on Electricity. It will suffice here, therefore, to mention its advantages for power transmission. Of these, the most important are high efficiency; extreme flexibility, for the power can be transmitted to any distance desired, and used in any suitable manner, while in driving workshops the shafting may be divided up into sections of any length; individual machines may be driven separately; any part of the works may be run independently of the rest; the buildings need not be laid out to suit shafting, and need not be so substantial, and any machine may be run or stopped without interfering with any other, or requiring long shafts to be driven; light is available as well as power; energy can be stored in batteries as a reserve, or to steady the load on the generating plant, and thus economise coal; there are no moving belts, ropes, or shafts in the space between the driver and the machine driven; and not least, without dwelling on other additional advantages, with electricity it is possible to keep a close watch on the performance of every part of the plant, and at once to note any falling-off in its efficiency. For transmitting power from a central point to a number of independent consumers, electricity is unrivalled, its high efficiency and flexibility being unique for this purpose, and there is no limit to the amount of power that may be transmitted by a single line. Withal, it is now possible to supply electricity in many places at a price which competes favourably with that of any other power

Pneumatic Power. Pneumatic power transmission possesses many advantageous features, accompanied, however, with certain inherent disadvantages. The latter have rendered it unsuitable for distributing power on a large scale, or transmitting it over great distances, though before the development of electrical transmission it was widely used. In this system, air is compressed by steam or other power-generating plant to a high pressure, and is transmitted through pipes to the place where the power is required, and there passed through air motors or other machines giving out mechanical power. The great difficulties met with in utilising air in this way are due to the heating of the air during compression, and to the converse phenomenon—the cooling of the air during expansion. Each of these characteristics leads to a serious loss of power. The act of compressing air or any other gas is necessarily accompanied by the evolution of heat, by reason of the work done on the gas. If the air thus heated were at once supplied to the air motor, losing but little heat on the way, it would be cooled to a corresponding extent during expansion, and discharged at a temperature not much below that of the atmosphere, the loss due to heating being then inconsiderable.

Compressing the Air. The air is usually compressed by compound steam engines, and in order to reduce the loss of power due to heating the compressed air, the compression is divided into two stages, the air being partially compressed, then passed through a cooling apparatus, and again compressed. By this means the temperature at which the air leaves the compressor is reduced. On the other hand, the expansion of the air in the motor produces very low temperatures, causing the moisture in the air to be deposited in the form of snow and ice in the exhaust passages. This is remedied by heating the air before it enters the motor, with surprising results, for the output is enormously increased, and it may be taken that reheating in this way is practically indispensable to high efficiency in pneumatic power transmission. Under the best conditions, the efficiency may be as high as 80 per cent., apart from the loss in the transmission line, which will absorb about 5 per cent. of the power per mile; under bad conditions the efficiency may be as low as

30 per cent. When the air pressure is very high, as in the case of torpedo charging, four-stage compressors are used, raising the pressure to 1.430 lb. per square inch. For ordinary purposes the pressure is from 40 lb. to 100 lb. per square inch, generally about 75 lb.

Uses of Compressed Air. Although compressed air can readily be used as above described in motors similar in principle to steam engines, giving continuous rotational motion to a shaft; it is far more generally employed in simple reciprocating apparatus, for driving which it is admirably adapted, though the efficiency is not more than 40 per cent., as it is not usually convenient to reheat the air in these cases. One of the most important uses of the system is the driving of rock drills in quarries, mines, and tunnels, and for coal-mining. The drill consists of a cylinder in which a piston oscillates, being controlled automatically by the compressed air, and carrying a drill which strikes rapid blows on the rock. The air exhausted from the drill helps to ventilate mine workings. The system has been applied to drilling and caulking iron and steel, riveting, pneumatic lifts for placing heavy work in position in lathes, etc., in many factories. In Paris, the Popp system of driving clocks pneumatically has worked well for many years. The clocks, which are merely dials, with hands worked pneumatically, are installed over a large portion of the city. Passenger and goods elevators are sometimes driven by pneumatic power, and parcels are blown through tubes to considerable distances, as in the underground telegraph system in Paris. One of the most common uses of compressed air is in the operation of the brakes of railway trains [see page 4696]. Air compressed to very high pressures—up to 4,000 lb. per square inch—can be stored in steel cylinders, and used to propel locomotives and motor-cars, the air being supplied through reducing valves, which lower the pressure to 150 lb. or less, to the cylinders of air motors. It will be observed, however, that the use of compressed air is due to questions of convenience, not efficiency or economy of power. An important consideration is the danger of explosion, due to the presence of oil or coal-dust in the air passages, which are ignited by the high temperature of the air.

Liquid Air. Liquid air—that is, air which has been cooled by expansion to a temperature so low (minus 192° C.) that it becomes liquid at atmospheric pressure — has been suggested as a possible means of power transmission, as it increases in volume 720 times in passing from the liquid to the gaseous condition. This process, however, involves gain of heat from external sources, such as the atmosphere and the apparatus in which it is used, the whole of the work, in fact, being done by this absorbed heat. Whether doing work or not, the liquid is constantly boiling away, due to the inflow of heat, and provision must be made to prevent the pressure of the gas from rising to a dangerous degree. The efficiency of the system would be excessively low, and the danger not inconsiderable.

Hydraulic Power. For many purposes, water pumped through pipes under great pressure forms a most convenient means of transmitting power, this system possessing certain advantages peculiar to itself. The source of energy is generally a steam engine, driving pumps, and thus feeding water into the pipes at a pressure ranging from 50 lb. per square inch (as in town supply) to 1,120 lb., or half a ton, per square inch. In the former (low-pressure) case the water is pumped up into elevated reservoirs, whence it is drawn as required, the pressure depending simply on the height of the reservoir above the point where the water is used. In the latter (high-pressure) case, the system is provided with accumulators, in which a quantity of water is maintained under the full pressure by means of weights attached to a piston working in a cylinder in communication with the pipes. When the pump supply is in excess of the requirements of the moment, the surplus water flows into the accumulator, raising the piston, and when the demand is in excess of the supply, the loaded piston descends, forcing the water through the pipes, and thus assisting the pumps.

Advantages of Hydraulic Power. Facility of storage is one of the chief advantages of hydraulic power transmission, as it enables the engines to run almost constantly loaded, while maintaining a uniform pressure in the mains. Only small powers are supplied at low pressure, the height of the reservoirs not usually exceeding 100 ft. ; but in high pressure systems, such as those installed for public supply in London, Manchester and Glasgow, large powers are conveyed with small quantities of water. The losses in transmission through friction in the pipes may be estimated at 5 per cent. per mile. The power is converted into rotary motion by means of hydraulic engines, consisting of pistons working in cylinders, and controlled by valves acting on the water supply ; owing to the incompressible nature of water, such engines cannot be run at high speeds, and therefore multiplying gear is generally necessary. When the engine is direct acting, the efficiency is about 85 per cent. ; the use of gearing reduces the efficiency. In engineering works, bridge construction, shipbuilding, etc., hydraulic power is widely used, being unexcelled in convenience and speed for riveting, punching, shearing, and bending. The machines used are very efficient and simple, consisting of little more than pistons and cylinders. For compressing bales of cotton, hay, etc., hydraulic presses are most suitable. In dockyards, railway stations, warehouses, etc., hydraulic cranes are very common, handling the greatest weights, and hydraulic lifts are met with almost everywhere. Huge hydraulic forging presses have largely superseded steam hammers for forging heavy iron and steel shafts, etc., while small hydraulic jacks, worked with hand pumps, are the most convenient and powerful portable lifting devices known. It will be observed that slow and intermittent motions are the most suitable for operation by hydraulic power.

POWER *concluded; followed by* PRIME MOVERS

GLUE, STARCH, AND INK

Manufacture and Testing Glue and Gelatine. Varieties of Starches and their Manufacture. Writing, Printing, and Other Inks

Continued from page 5150

By CLAYTON BEADLE and HENRY P. STEVENS

GLUES AND ADHESIVES

We can trace back the use of glue as an adhesive to the times of the ancient Egyptians, who in the reign of Thotmes or Thutmosis were certainly acquainted with the art of *veneering*—that is to say, coating one piece of wood with a thin layer of a more valuable material. In the sculptures of Thebes a workman is represented engaged in this work, while another is spreading glue with a brush. The pot for the glue is there standing on the fire, and a piece of glue with its peculiar conchoidal (shell-like) fracture. This attests to the use of glue by the Egyptians 3,300 years ago (Lambert). Besides this, there are plenty of references to glue in the literature of the ancients and the Middle Ages.

What is Glue? Glue is an animal product obtained from quite an assortment of substances, such as skins and other tissues, cartilage, hides, bones, fish bladders, fish scales, and all sorts of refuse odds and ends by boiling them down with water and suitably purifying the liquor. On cooling, it sets to a stiff jelly, the consistency and colour of which will depend on the raw materials and the purity of the final product. Glues may be roughly divided into three classes—skin glues, bone glues, and fish glues. These will be dealt with in order.

Gelatine is another product of the same nature as glue, and may be defined as a very pure, almost colourless variety of glue in the manufacture of which every possible care has been taken. The distinction between glue and gelatine is not very well defined, and the terms are often applied somewhat promiscuously. The points in which glue and gelatine differ are enunciated by Rideal as follows:

"Gelatine is made in pale, nearly colourless, thin sheets, and is used for purposes in which absence of taste, odour, and colour, with firmness of jelly and easy solubility, are required.

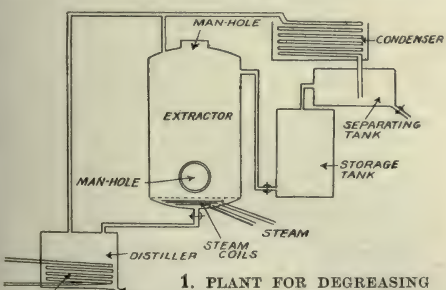
"Glue, on the other hand, is employed for its adhesiveness, stiffness, and elasticity, and is met with in the familiar thick and dark sheets."

The mode of manufacture of gelatine is, on the whole, similar to that of glue, and we shall therefore be content to indicate in the proper place, when describing the manufacture of glue, any differences in treatment or further precautions which it may be necessary to take.

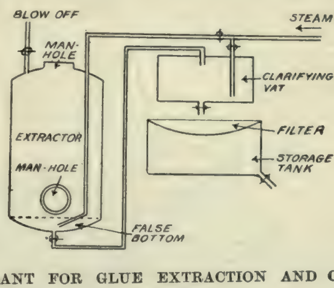
Skin Glue. This is obtained from the waste pieces of hide, etc., rejected by the tanner, who removes those portions which are unsuitable for conversion into leather, as, for instance, the heads and feet of calves and sheep, and waste, such as tail pieces of oxen, ears, clippings, etc. The hide of old animals is said to yield the best glue. The material, or "stock," is steeped in wooden vats, or cement-lined lime-pits, where the hides are exposed to the action of lime and water for two or three weeks, or longer, according to the class of material. A 2 per cent. milk of lime is used, and removes any fat adhering to the hide by saponifying it (converting it into a lime soap). It also swells the tissue, and helps to remove dirt and any blood or fleshy substance remaining attached to the hides. From time to time during the process the skins are raked about so as to expose fresh surfaces to the action of the lime. The cuticle, or outer skin, having been softened by this treatment, the hair can more readily be scraped off. After this, the hides must be thoroughly washed to remove every trace of lime, for which purpose it is not unusual to give them a preliminary souring with weak hydrochloric acid. This forms a soluble salt (calcium chloride) with the lime, which is easily washed out with water. The washers are provided with mechanical agitators, which keep the hides gently stirred until the operation is complete. The hides are then taken from the washers, pressed to remove excess of water, and hung up to dry.

New Inventions. In some works the use of lime has been given up, and a weak solution of soda is used instead, with this advantage—that the hides are much more easily washed free from alkali. The material is then treated with sulphurous acid solution in wooden vessels. This process, which we owe to Dr. Terne, loosens the skins so that on extraction the resulting liquors are clear and almost water white, and the glue or gelatine has an excellent appearance.

Where lime is still used, the souring with hydrochloric acid is likely to be replaced by a new process, devised by Francis T. Oakes (United States Patent 998,293), in which the hides, after washing with



1. PLANT FOR DEGREASING BONES



2. PLANT FOR GLUE EXTRACTION AND CLARIFICATION

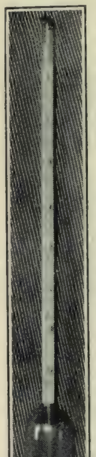
water, are immersed in a bath containing 5 per cent. of glucose syrup and 1 per cent. of sulphur, reckoned on the weight of the skins or hides, with the further addition of 1 lb. of yeast for every 1,000 lb. of material treated. The bath is heated to a temperature of 95 to 100° F., and is allowed to stand twenty-four hours for fermentation to set in before immersing the hides. There is no need to keep the hides in constant motion; it suffices to stir them every hour or so to ensure uniformity of action; even heavy bull hides will be freed from lime and be left in a free and open condition at the end of eight hours. The process may be made continuous by removing half the liquor and adding further quantities of glucose, sulphur, and yeast after each lot of hides is removed, and before a new "pack" is added.

Extracting the Glue. The hides are now taken to the boiling vat, which consists simply of a large open vessel, with a coil of steam-pipes under a false bottom through which live steam can be forced into the vat. Under this treatment the mass of hides gradually sinks down, and the hot liquid dissolves out the glue. It must not, however, be supposed that the hides contain glue in the form in which we know it. The hot steam brings about chemical changes in the complex substances of which the hides are composed, liberating the glue, which dissolves in the liquor. As the material is gradually exhausted, fresh hides are added, and when the liquor is sufficiently concentrated (as shown by allowing a little to cool, and testing the firmness of the jelly), it is run off, strained through a sieve, and allowed to settle in vats for clarification. There are several chemicals which can be used to clear the solutions, but potash alum is usually found to work best. The liquors must be kept hot all the time by appropriate steam coils.

It remains only to concentrate the liquors sufficiently, which is most economically effected by treatment in some form of vacuum pan or multiple effect evaporating plant. [See Soda Recovery in Papermaking.] Before going further, we shall trace the production of glue from bones to the stage we have now reached in treating hides.

Bone Glue. Bones consist for the most part of mineral substances—phosphates and carbonates of lime and magnesia—in conjunction with certain organic constituents. These latter yield the glue liquor on extracting with hot water, but all bones as they reach the glue works also contain a certain amount of fat. The percentage both of fat and glue will vary with the age of the animal, as the bones of older animals contain a larger proportion of mineral matter. Thigh bones (marrows) yield more fat than heads, ribs, and shoulder-blades. On an average, the proportion of fat may be put at 17 per cent. to 18 per cent. in the former, and at 12 per cent. to 13 per cent. in the latter (Lambert). On the other hand, the long bones of limbs and vertebræ yield less glue. The organic matter other than fat from which the glue is derived will amount to 21 per cent. to 22 per cent. These figures refer to fresh bones, but those which have already been put to other use, such as soup-making, will yield much less of both fat and gelatine.

Degreasing Processes. Removing fat, or "degreasing" the bones, is the first operation, and used to be carried out by boiling in an open vessel and skimming off the fat. This method was subsequently improved upon by heating in a closed vessel under pressure (40 lb. to the square inch), and the yield of fat (bone grease), a product of considerable value to the soap-maker, was thereby increased from 5 per cent. to 7½ per cent., but at the same time a large proportion of the glue was extracted and obtained in admixture with the fat, necessitating subsequent separation. In the more modern methods the fat is removed by dissolving it out with a volatile organic solvent, such as benzene, whereby the bones are left in an unaltered state for glue extraction, and the fat can be obtained by evaporating off the solvent, which is then used over again in the next operation. The plant [1] consists of an upright boiler or extractor to take five tons of bones, which, after sorting and partial crushing, are introduced through a manhole in the top. Solvent is then run in. This usually consists of shale spirit or petroleum, boiling about 100° C., and free from the higher boiling constituents, so that it is completely volatile at temperatures attainable in the distilling apparatus—say, 135° C. Steam is now admitted to steam coils at the bottom of the extractor so that the hot solvent dissolves the fat; part of it, however, distils away through a pipe at the top, carrying with it moisture from the bones, and the vapours are led to a suitable condenser. As soon as the moisture has gone off, the solvent with the fat in solution is run off to the distiller, and a fresh quantity of solvent is admitted to the extractor. The distiller is provided with steam coils, so that the contents may be heated and the solvent driven over into the condenser. The process may be repeated three or four times, when practically all the fat will have been extracted. There remains to be recovered only a portion of the solvent still adhering to the bones, for which purpose live steam under 70 lb. or 80 lb. pressure is driven through the mass, carrying the solvent with it away to the condenser. Under the condenser is the separating tank, where the light solvent is drawn off from the aqueous liquor into the storage tank for use over again.



3. GLUE TESTER

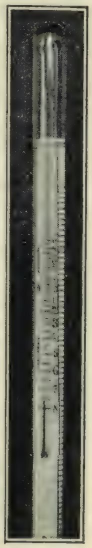
Cleansing Process. The degreased bones, which will not retain more than ·2 per cent. of fat, are removed from the extractor, and put through a slowly revolving drum built horizontally. The drum is made of stout wire gauze of wide mesh, and as the bones pass down, any pieces of foreign matter, dirt, etc., drop out, and are eliminated, while the purified degreased bones, containing 5 per cent. or 6 per cent. of nitrogen in a form removable as glue, pass on to the glue-boiling process.

Boiling Process. This process is similar to that used in treating hides and is carried on in a large steel boiler [2] provided with a manhole at the top for introducing the raw material, and another at the bottom for withdrawing the exhausted material. As the extraction is carried out by live steam under pressure the boilers must be somewhat differently constructed from those used for treating hides. The live steam enters at the base and is distributed under a false bottom, on which the bones rest, and may be blown off from a pipe leaving the boiler at the top.

The pressure is allowed to rise to 15 lb., at which it is maintained for a couple of hours, when it is reduced to 5 lb. It is found that lowering the pressure causes the glue which has formed in the

pieces of bone to come to the surface (Lambert). When the extraction is complete the bones are washed down with water from a sprinkler in the top of the boiler and the liquor is run off. The bones yield about 40 per cent. of their weight of glue as the result of double extraction; only a very small amount—about 4 per cent.—remains in the bones.

Clarification and Concentration of Liquors. As the glue-liquors leave the boiler they have a concentration of about 20 per cent., but they require to be further evaporated so that on cooling they solidify to a firm jelly of such consistency that it can be conveniently handled—that is, moulded, cut up, and dried. Previous to concentration, the liquors are heated with sulphate of alumina or alum in the same manner as the extract from hides were in the clarifying vat. About one half per cent. of alum is required, reckoned on the dry weight of the glue, and the liquors are heated to boiling for ten minutes by means of live steam. On standing, the heavy impurities settle to the bottom, and the lighter ones remain as a scum upon the surface and are removed by filtration through gauze of fine mesh or coarse calico.



4. GLUE-TESTER STEM
Upper Part

If, however, the glue-liquors have been prepared from sound "stock" and properly cured, the first run of liquor comes away in a practically clear condition from the boilers. A large and relatively shallow vat is all that is necessary for clarification. The liquors are run into the vat and given sufficient time to allow the heavy impurities to settle out. The liquors from subsequent extractions are usually muddy, and instead of attempting to clarify them, it is the custom of some manufacturers to incorporate with them substances such as zinc white or barytes to produce the so-called "Russian glues."

In the preparation and concentration of glue-liquors, an apparatus [**3** and **4**] is much in use for ascertaining the percentage of glue in the liquors. This glue-tester [**3**] is a form of hydrometer [see PHYSICS], with a compensating thermometer made in one piece. To find the percentage of glue the instrument is immersed in the liquor and the reading taken at the point where the stem rises above the surface. The figure so obtained is corrected for temperature by a reading of the thermometer scale on the back of the stem and shown on somewhat magnified scale in **4**. Thus, supposing the instrument sank to the mark 25 on the large scale, it would be necessary to subtract 7·7, thus 25 − 7·7 = 17·3, which gives the percentage of glue straight away.

The concentration is best carried out in a double effect vacuum evaporator. (We cannot go into the working of this plant here, but it is described under Papermaking, where it is used for concentrating caustic liquors.) By this means our liquors will now have a dry glue content of 32 to 35 per cent., according to the time of year. As the consistency of the jelly is affected by the temperature a more concentrated liquor is required in summer than in winter.

Bleaching. The concentrated liquors are often bleached at this stage to improve the colour, but the product has not the qualities of a good class gelatine, where freedom from colour is due to careful selection of raw material and precautions which have been taken in the process of manufacture.

In any case, sulphurous acid is almost universally employed; more active bleaching agents are out of the question, as they would attack and destroy the glue.

Bleaching powder has been used in Germany, but the operation has to be most carefully watched and stopped at the right stage to prevent spoiling the glue. Residues of bleach remaining in the liquors necessitate the addition of an anti-chlor such as sodium sulphite. Sulphurous acid is made by burning sulphur in special furnaces [see Acids and Alkalies, pages 4625 and 4770]. The gas is passed through the glue-liquors contained in tanks kept hot by suitable steam coils.

Sulphurous Acid Process. In the manufacture of high-class glues and gelatines the bones may be treated with acid before extracting the glue. In the older processes for the manufacture of gelatine from bones they were immersed in hydrochloric acid a sufficient time to dissolve out the calcium phosphate and other mineral matter, and, after being thoroughly washed, were bleached by immersion in sulphurous acid liquor. The two operations are now frequently combined in one. The air-dry bones (English Patent 2175, 1894) are exposed to the action of sulphur dioxide for a long time in closed vessels until they have taken up some 10 to 12 per cent. of their weight of the gas. Bones that are too dry must first be moistened. The chemical reaction that ensues may be thus represented:

$$\underset{\substack{\text{Insoluble}\\\text{bone}\\\text{material}}}{Ca_3(PO_4)_2} + \underset{\substack{\text{Sulphur}\\\text{dioxide}}}{SO_2} + \underset{\text{Water}}{H_2O} = \underset{\substack{\text{Acid calcium}\\\text{phosphate}}}{2\,CaHPO_4} + \underset{\substack{\text{Insoluble}\\\text{calcium}\\\text{sulphite as}\\\text{sediment}}}{CaSO_3}$$

The calcium phosphate, which is soluble in weak acid, may be removed by leaching, leaving the glue mass intact. The bones, which have become brittle, are easily extracted, leaving the calcium sulphite as a sediment. The glue-liquors have an acid reaction, and are somewhat muddy. Treatment with lime, however, clears them and neutralises the acid.

This process is suited to bones which have not been degreased, as the fat separating from the glue-liquors rises clear from the hot liquor.

A modification of this method is worked in Germany. After treating with sulphur dioxide, the bones are sprinkled with water and re-treated under a pressure of $1\frac{1}{2}$ to 2 atmospheres at the ordinary temperature in lead-lined digesters. The calcium sulphite is thereby converted into bisulphite.

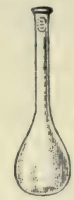
$$\underset{\substack{\text{Insoluble bone}\\\text{material}}}{Ca_3(PO_4)_2} + \underset{\text{Water}}{4\,H_2O} + \underset{\substack{\text{Sulphur}\\\text{dioxide}}}{4\,SO_2} = \underset{\substack{\text{Soluble calcium}\\\text{phosphate}}}{CaH_4(PO_4)_2} + \underset{\substack{\text{Soluble calcium}\\\text{bisulphite}}}{2\,CaH_2(SO_3)_2}$$

Thus, both this and the acid phosphate may be extracted with water leaving the pure glue mass behind.

When extracting gelatine, to preserve a good colour the temperature of the liquor should not be allowed to rise above 85° C. Some of the best gelatine is clarified with albumen, such as blood or white of egg, in the place of alum.

Moulding and Cutting. The clarified, concentrated, and bleached liquors are jellied by pouring into moulds or cooling-boxes, made of strong sheet zinc, so that large flat cakes are obtained five or six inches thick, or the liquor is run on to glass tables the surfaces of which are kept cool by a current of cold water underneath.

The blocks of jelly are cut into small slabs by wire cutting frames similar to those used in making wire-cut bricks or soap-slabbing machines. Either the block of jelly is put in a box, the sides of which are provided with a number of slots so that a wire fixed on a frame like a fretsaw may be passed down through the block and guided by the slots on each side, or else the block may be cut up into the correct number of slabs in one operation by forcing it against a frame across which wires are stretched at suitable intervals. In another machine the block of jelly is carried forward on an endless belt and sliced by a number of fixed wires which are set diagonally to the cutting plane, and therefore at some distance apart, so that one slice only is cut at a time. It is claimed that by this means a regular and uniform action is ensured with less strain on the wires, which consequently last longer.


5. KJEDAHL FLASK

In Hewitt's process a hollow steel cylinder revolves slowly, just dipping into a trough containing the glue-liquor. A current of cooled brine is drawn through the cylinder, and the flow of brine and the speed of the cylinder adjusted so that the layer of glue adhering to the surface of the cylinder solidifies in less than one revolution, and the firm jelly is wound off in the form of an endless ribbon, which then passes to an appropriate machine which cuts it into pieces of suitable size.

In some countries the rooms in which glue-liquors are solidified have to be cooled in the hot weather. This is best effected by pipes running along the ceiling and carrying cooled brine. [See Food Preservation.]

Drying. This is one of the most delicate operations in glue-making, and is subject to all sorts of difficulties. For some reason or another thunder in the air is said to exert an especially harmful influence, and to spoil whole batches of glue. No explanation has been offered beyond the suggestion that the effect is possibly due to the ozone produced in stormy weather.

The glue must not be dried too slowly, or the "bacillus subtilis," which has the power of liquefying glue, may get a foothold, and all sorts of other bacteria and moulds will develop.

From this it will be seen that the old-fashioned mode of drying glue in the open could be carried on only at certain times of the year, and in certain weathers, and even then with very uncertain results.

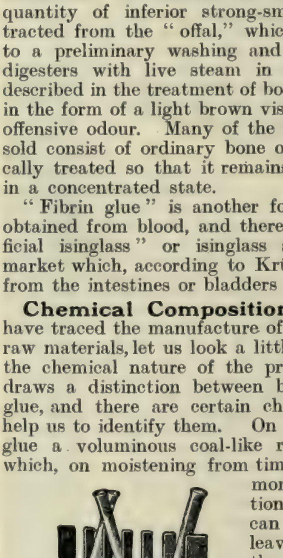
Modern Methods. At the present day glue is dried generally in tunnel dryers. The sheets of glue are placed on netting (preferably wire netting, as the cotton threads often used are a breeding ground for bacteria), and stretched on frames which are piled in stacks in a small waggon made to run on narrow rails through the tunnel. The tunnel may be six or eight feet broad and high and 250 ft. long; it is usually lagged to minimise the influence of the temperature of the surrounding air. A current of air is drawn through the tunnel, the temperature of which must be carefully regulated, as the melting point of the undried jelly will often not exceed 25° C. It will therefore be necessary in hot weather to cool the air in a refrigerator before allowing it to enter the tunnel, otherwise the glue will melt and tend to run through the nets. On the other hand, the drying must not be too rapid, or a tough film will be formed on the outside, offering a barrier to further drying of the interior, and preventing gradual and regular contraction of the mass. This skin imprisons numerous bubbles or air spaces, producing an unsightly appearance and diminishing the value of the finished glue.

As a further precaution against putrefaction, the air drawn through the tunnel dryers may be charged with small quantities of chlorine or sulphur dioxide gases.

Fish Glue. The purest form of fish glue, or "isinglass," is obtained from the floating bladders of various species of fish, especially the sturgeon. The bladders are cut up into strips and softened in hot water until the muscular outer coat can be stripped off. The residue is freed from fat, blood, and other impurities, and after drying in the air, forms the raw material for glue extraction. In addition to this, a considerable quantity of inferior strong-smelling glue is extracted from the "offal," which is first subjected to a preliminary washing and then extracted in digesters with live steam in a manner already described in the treatment of bones. It is obtained in the form of a light brown viscous liquid, with an offensive odour. Many of the liquid "fish glues" sold consist of ordinary bone or hide glue chemically treated so that it remains liquid even when in a concentrated state.

"Fibrin glue" is another form of animal glue obtained from blood, and there are various "artificial isinglass" or isinglass substitutes on the market which, according to Krüeger, are prepared from the intestines or bladders of sheep and goats.

Chemical Composition. Now that we have traced the manufacture of glue from different raw materials, let us look a little more closely into the chemical nature of the products. The trade draws a distinction between bone glue and hide glue, and there are certain chemical tests which help us to identify them. On burning a piece of glue a voluminous coal-like residue is obtained, which, on moistening from time to time with ammonium nitrate solution, and reheating, can be burnt away, leaving nothing but the mineral matter originally contained in the glue in the form of ash. The quantity obtained from a properly prepared glue or gelatine is very small, not exceeding two or three per cent. Bone glue yields a fusible ash of neutral reaction, consisting of the phosphates and chlorides of calcium and magnesium; these elements may therefore be detected in a solution of the residue by the ordinary chemical reactions [see Analytical Chemistry, page 4407]. The ash of hide glues does not fuse so easily, and consists of caustic lime, probably arising from lime used in the process of "liming" the skins.


6. KJEDAHL FLASKS ON STAND

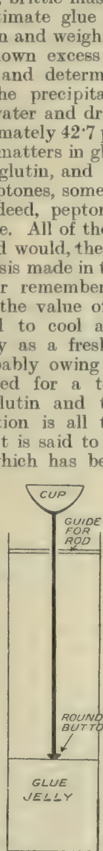
But whatever its origin, glue is composed mainly of two nitrogenous substances, "glutin" and "chondrin," closely resembling one another in appearance and properties. In chemical composition, too, there is scarcely anything to distinguish them, both containing 50 per cent. of carbon and

6·6 to 6·7 per cent. of hydrogen. Glutin, however, contains more nitrogen, 18·5 per cent., as against 14·5 per cent. in chondrin, the remainder in both cases being oxygen. The adhesive properties are attributed to glutin and, although both glutin and chondrin form jellies, the latter forms the firmer of the two. If this be so, glutin should be the main constituent of a glue for adhesive purposes, and chondrin where high gelatinising power is required, as in the preparation of table jellies.

Small quantities of acids, alum, lead acetate, etc., precipitate chondrin from an aqueous solution, while solutions of glutin are not so precipitated.

Chemical Reactions. One of the most characteristic reactions of a glue or gelatine solution is obtained on adding a little solution of tannic acid, whereby a white, flocculent precipitate of tannate of glutin is obtained, which is soluble in alkalies. On drying it forms a hard, brittle mass.

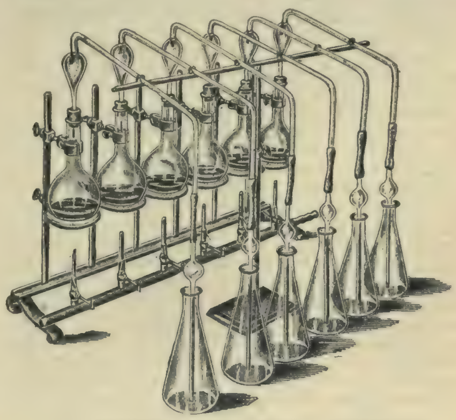
Attempts have been made to estimate glue by precipitating it with a tannin solution and weighing the precipitate, or by adding a known excess of tannin, filtering off the precipitate, and determining the tannin in the filtrate. The precipitate, when thoroughly washed with hot water and dried at 105° C., is said to contain approximately 42·7 per cent. of glutin. But the nitrogenous matters in glue consist of other substances besides glutin, and include chondrin, albuminoses, and peptones, some of which are of little or no value; indeed, peptones actually detract from the value of glue. All of these are precipitated with tannic acid, and would, therefore, be reckoned as glutin in an analysis made in the above manner. When it is further remembered that "over boiling" detracts from the value of a glue, and that "a solution allowed to cool and remelted has not the same tenacity as a freshly prepared solution" (Lambert), probably owing to the formation of peptones, the need for a test which will discriminate between glutin and the peptones formed by its decomposition is all the more evident. On the other hand, it is said to be a distinct advantage to use glue which has been dried down and dissolved up again for sizing paper.



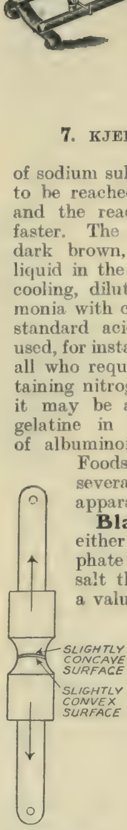
8. LIPPOWITZ SHOT TEST FOR GLUE CONSISTENCY

The determination of the percentage of nitrogen, best effected by Kjedahl's method, also fails to discriminate between glutin and other nitrogenous substances, although this test is of considerable value in estimating the percentage of glue in nonnitrogenous substances generally.

Kjedahl Estimation. Organic substances containing nitrogen (as albumens or proteids) are completely decomposed when digested with hot strong sulphuric acid. The nitrogen passes into the form of ammonia and remains, in combination with sulphuric acid, as ammonium sulphate. An accurately weighed quantity—say, one gramme or more—is placed in a flask [5] with a capacity of two or three hundred cubic centimetres and a measured quantity of strong sulphuric acid is added. The acid need be measured only roughly, and 10 or 20 c.c. will suffice. The flask is heated with a small flame and much sulphur dioxide gas is evolved. Fig. 6 illustrates the process of heating three such flasks. At this stage the contents may have a tendency to foam over and must be carefully watched. Then add 4 grammes (approximately) of sodium sulphate for every 10 c.c. of sulphuric acid taken, and heat up the flask, so that the contents just boil. The addition


7. KJEDAHL DISTILLATION APPARATUS

of sodium sulphate will allow a higher temperature to be reached than would otherwise be the case, and the reaction being more energetic proceeds faster. The charred mass gradually changes to dark brown, then yellow, and finally colourless liquid in the course of two or three hours. After cooling, dilute with water and distil off the ammonia with caustic soda, collecting in an excess of standard acid. This method is very extensively used, for instance, by the physiological chemists and all who require to analyse organic products containing nitrogen, such as gelatine, glue, etc. Thus it may be applied to determine the amount of gelatine in (tub-sized) paper or the percentage of albuminoids in cattle food, etc. [see Cattle Foods]. It is often necessary to make several analyses at the same time, when the apparatus shown in 7 will be found suitable.



9. KISSLING'S GLUE TESTING APPARATUS

Blank Determinations. Should either the sulphuric acid or sodium sulphate happen to contain any ammonium salt the calculated result will give too high a value, as this and any other nitrogenous matter will be reckoned as contained in the substance analysed. It is usual to make a "blank" estimation, which is carried out in exactly the same manner as the foregoing, using the same quantities of reagents, heating the same length of time, etc., but without adding any of the substance to be tested. If the titration shows that some of the standard acid in the flask has been neutralised, the calculated amount of nitrogen must be deducted from the total nitrogen found. Should the blank experiment show a considerable percentage of ammonia distilled over, there is something seriously wrong. Either some alkali has been carried over or the reagents are impure, and the analyses must be repeated.

Zinc Sulphate Method. Trotman and Hackford recently claim to have solved the problem "and to have shown that good and bad glues may

be chemically differentiated by means of the ratio between total nitrogen and nitrogen in substances precipitated by zinc sulphate, and that any carelessness in manufacture which increases the quantity of nitrogen incapable of such precipitation decreases to a corresponding extent the value of the finished glue." The method is carried out as follows: One gramme of finely powdered glue is dissolved in not more than 20 c.c. of water. To the hot solution crystals of zinc sulphate are added in excess to saturate the liquid. It is then well stirred with a glass rod and filtered through a funnel containing a plug of glass-wool forced into the stem and washed with saturated zinc sulphate solution. The glass-wool and precipitate are then introduced into a Kjedahl flask and the nitrogen is estimated in the usual manner.

Glue is best dissolved by first allowing it to stand overnight in cold water, which causes it to swell greatly, and then pouring off the water and dissolving in a fresh quantity of hot water. The glue-pot should not be heated over a free fire, as lumps of partially dissolved material may stick to the bottom, and char, but the vessel containing the glue should be placed inside a larger vessel containing the hot water. Prolonged heating injures the glue, detracting from its consistency, and increasing the tendency to foaming, both effects, according to Trotman and Hackford, being due to formation of peptones. A glue which foams badly is of little use in making joints, especially when applied by means of a rotary brush, as the air-bubbles spoil the joint; in dressing fabrics a glue of this sort produces an uneven deposit. To test the tendency of a glue to foam, 25 c.c. of a 10 per cent. solution is poured into a graduated tube 70 cm. long, having a capacity of 70 c.c., and warmed in a water bath to 60° C. The tube is then corked and vigorously shaken. The height of the foam, termed the "foam figure," is read off, and on comparing a number of samples in this manner their relative value may be ascertained.

Consistency. It should be remembered that most glue tests are only relative, and to obtain results of value one sample must be taken as a standard by which to compare the others. This consideration applies to tests of consistency or strength of a glue jelly. Equal quantities of the glue samples are weighed out, and 10 per cent. jellies prepared. It is as well to weight the swollen glue that has stood in water overnight. As a general rule the better the glue the more water it takes up. The consistency of the 10 per cent. jellies may be compared by pressing them gently with the finger tips. Notwithstanding the "personal equation," different persons will usually grade the jellies in the same order.

Lippowitz applies the test in a different manner. Five parts of glue are dissolved in 45 parts of water, and the liquid poured into a cylinder [**8**], allowed to cool, and to stand twelve hours. A cup is fixed to a metal rod provided at the lower end with a button shaped like a bolt head, which rests on the top of the jelly, and the rod passes through a guide fixed to the top of the cylinder. Shot is poured into the cup until the bottom end of the rod ruptures the surface of the jelly.

Tenacity. No satisfactory method has yet been devised for testing the tenacity of glues. Weidenbusch works up powdered gypsum with a 10 per cent. solution slightly warmed, and moulds it into narrow rods. A rod is tested by laying it across a metal ring, and pouring mercury into a cup suspended from the middle of the rod. The weight of mercury required to break the rod is a measure of the adhesive properties of the glue.

Other experimenters glue together the surfaces of wood or metal and determine the force required to wrench them apart. The disadvantage of using wood lies in the fact that the wood itself at times gives way instead of the glued surfaces. Kissling uses nickel-plated iron [**9**], but objections have been raised to the use of a smooth metallic surface for testing glue intended for applying to the uneven surface of a piece of wood. From the papermaker's point of view its strength-giving qualities should be determined in the manner described for gum arabic.

Glue and Gelatine. We have enumerated some of the principal tests for glues, let us now compare the results of tests made on a fine brand of gelatine and on an average sample of dark Scotch glue. It was found that the tenacity of the Scotch glue was rather greater than that of the gelatine. On preparing 5 per cent. jellies of each the consistency of the gelatine jelly was 10 times as great as that of the glue in cold weather, while in warm summer weather the glue was liquid while the gelatine was still a stiff jelly. In some cases it is of interest to compare the viscosity of glue solutions. In the case we are considering the viscosity of a 5 per cent. gelatine solution was twice that of the corresponding glue liquor.

Uses of Glue. In the first place glue is extensively used by woodworkers and cabinet-makers, for veneering woods and other purposes. It is also used as an agglutinant in the manufacture of matches, to attach the mineral composition which forms the head of the match. The textile trades use large quantities of the best grades for dressing and finishing fabrics, and also for mixing with the colouring matter in calico printing. In combination with glycerin, gelatine is used in multiple copying presses, and, with chromium salts, in the manufacture of printing-rolls. It is also used for coating photographic plates, and for "tub sizing" and coating paper. Gelatine is extensively employed in culinary work, and in the confectionery trade. Although recent research seems to show that its nutritive value is probably slight, jellies for table use will no doubt continue to find favour.

The adhesive properties are very great, and various forms of liquid glue, usually in collapsible metal tubes, are in general use as a substitute for the glue-pot. Fig. **10** shows a piece of glue in which a small quantity of glue jelly has been allowed to dry down. So firmly has it adhered in places to the surface of the glass that on contracting it has torn little pieces bodily away, producing a peculiar fern-like pattern. The destruction of glass and porcelain vessels in which glue or gelatine has been inadvertently allowed to dry down is only too familiar to the student.

Casein Cements. The substance known as *casein*, which is now manufactured in considerable quantities from milk after separating the fat, has been recently applied for a number of purposes, among others for the production of adhesive cements. An ordinary solution of casein resembles in many respects a glue solution, and is prepared by dissolving casein at a temperature not higher than 60° or 70° C., with the aid of a small quantity of ammonia or carbonate of soda, preferably the former, as the ammonia gradually evaporates, leaving only the casein behind.

Another method of dissolving casein is to mix 150 parts with 75 parts of sodium tungstate. It is then gently warmed, stirred, and poured into

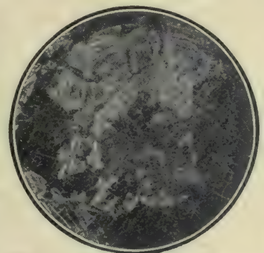
moulds. The product can be used like glue by dissolving in water, or a solution in water may be prepared for use.

For many purposes casein is first softened in lime water, and is then treated with further quantities of lime and water glass (German patent 116,355) as follows: 12½ parts of ground casein powder is mixed with three times the quantity of clear lime water, and allowed to stand for 48 hours. The mass of swollen casein is further treated with 2½ parts of lime, and 25 parts of water, and vigorously stirred for 20 minutes. The mixture is further treated with 17½ parts of water glass, and again thoroughly mixed. After standing for some time the mass is further diluted.

Besides alkalies and ammonia, a number of other substances may be used for dissolving casein and preparing a liquid glue, such as borax, sodium phosphate, sodium tungstate, and sodium silicate. This last is said to yield the best cement for porcelain, although cements for almost every purpose can be prepared by suitable choice of solvent. [For uses of casein as distemper see PAINTS AND POLISHES.]

Adhesives of Vegetable Origin. These usually belong to one of two classes. In the first class we may place gum arabic. In the second starch, dextrin, etc. [see below].

Gum arabic is an exudation from the bark of certain varieties of acacia trees, and never comes from Arabia, as its name might lead one to infer, but from parts of Africa, particularly the North-east, West, and South. That coming from the North-east is generally regarded as the highest quality. Senegal and the Cape yield similar gums. A new source of supply has recently been discovered in Central Asia, in the districts traversed by the Bagdad Railway.



10. GLUE DRIED ON A PIECE OF GLASS

Some of the gums do not dissolve in water, but form a thick, slimy mass, and are used for thickening polishes, etc. The true gum arabic is soluble in water, and gives a solution which reacts weakly acid to litmus. This acid reaction, however, is not brought about by the gum itself, but by traces of sulphurous acid used for bleaching and purifying it.

The gums are usually found in conjunction with small quantities of mineral bodies, sugars, tannin, colouring matters, etc., and to prepare the pure substance they are dissolved in water and the solution *dialysed*—that is, placed in a circular tray like a drum-head, with a parchment bottom. This tray is floated on a pan of water. Most of the impurities pass through the membrane, leaving the solution of pure gum behind, which can be further purified by precipitating with alcohol. Very little is known as to the chemistry of the pure gum, whether it is a single substance or a mixture of substances, although the latter view is the more probable. When boiled with dilute sulphuric acid a peculiar five carbon sugar known as *arabinose* is produced.

Characteristics and Adulterants. The varieties of gum arabic which are found on the market are characterised by their strength, colour, and solubility, as well as by the country from which they are imported. Good varieties dissolve completely in their own weight of water, and as easily in cold water as in hot.

Solutions of gum arabic react in a peculiar manner with starch paste, and convert the latter into dextrin. The two, therefore, cannot be combined in the preparation of adhesive substances.

In appearance, gum arabic consists of rounded or long-shaped lumps, varying in colour, odourless, and with only a very faint sweetish taste. The outer surface is often scarred and cracked. Gum arabic is frequently adulterated, especially as the better sorts are not easily obtained. It should be carefully examined, and appropriate tests applied according to the purpose for which it is required. Dextrin is a common adulterant, and may be detected by the following test, depending upon the fact that the solution of gum is precipitated in its gelatinised state by ferric chloride. A sample is dissolved in two parts of water and a few drops of concentrated solution of ferric chloride added. The solution gelatinises, owing to the presence of "arabin." Should, however, the sample be adulterated with dextrin, a whitish precipitate is formed on shaking with water. When only the pure gum is present, the gelatinous precipitate remains unchanged. Dextrin may also be detected by testing with Fehling solution, as commercial samples always contain sugar.

Gum arabic gives characteristic colours when treated with acid solutions of certain phenols, which are useful for purposes of identification. To separate a mixture of gum arabic and gelatine or glue, the property of tannin to precipitate the latter substances may be made use of, the gum arabic remaining in solution, which may be filtered off from the precipitate.

Adhesive Power. To test the adhesive property of gum arabic, strips of paper are saturated with a weak solution, and after drying, their strength is tested in a paper-testing paparatus. [See Paper Testing.] It will be found that the paper, after soaking in the gum, has become much stronger, at times twice as strong as the untreated paper. To arrive at a figure for the adhesive quality, the strength of the untreated strip is subtracted from that of the treated. The weight of gum taken up by the paper is also determined by weighing the paper before and after treatment. Imagine this weight of gum spread over a surface equal to that of the strip of paper, a figure for the strength may then be calculated on the unit sectional area.

As an adhesive, gum arabic is used for paper almost entirely, especially for stamps, envelopes, labels, etc., although mixtures of other and cheaper substances are often used for the same purpose.

For coating paper, a solution of 19 to 21 Bé. is strong enough. Such a solution is easily applied, and gives a coat having the necessary adhesive quality.

It is of importance that not more gum than necessary should be laid on to the surface of paper. Thus, according to Dr. Krüeger, the stamps of the Swiss Government are too heavily laden with gum. When fixed on to an envelope they are easily shifted before the gum has dried hard. The addition of borax as a thickener to solutions of gum arabic is recommended, and sulphate of alumina or calcium nitrate may also be used. They prevent the solution of gum penetrating too far into paper.

STARCH

Starch is an organic substance belonging to a class of bodies termed *carbohydrates*, and is composed of carbon, hydrogen, and oxygen in the proportions represented by the formula, $C_6H_{10}O_5$. It is very widely diffused in the vegetable kingdom, being an invariable constituent of plants, occurring especially in the seeds of the cereals and in roots and tubers, such as the potato. For manufacturing purposes, a plant is chosen which is easily cultivated besides containing a large proportion of starch, different raw materials being treated in different countries, according to climatic and other conditions. In England, rice starch, made from imported material, is the chief product, and is usually preferred for laundry work. In Germany, large quantities of potatoes are grown especially for the purpose of making starch, and although the ordinary edible potato contains some 13 per cent., the cultivation has made such progress that the average percentage has been raised to 20 per cent. and even more. Although some potatoes are used in the United States, they are not cultivated specially for the purpose, the main raw material consisting of maize or Indian corn. In 1904 some 110,290 tons were manufactured from this substance [see "Census Bulletin"], and as maize contains a fair proportion of proteid bodies (especially in the germ) as well as oil, it is sufficient to remove the greater part of the starch, leaving a residue containing the remainder of the starch, together with the proteids for use as cattle-food. Potato starch fetches a higher price than maize starch, as it is preferred for some manufacturing operations, especially in the textile industries.

Many other plants are worked up for the production of foodstuffs, such as cassava, arrowroot, etc. Much of the starch manufactured is converted into glucose for British gum, syrups, etc., and, in addition to the large quantities used in laundry work, it is also applied for sizing paper and cotton goods, dressing cloth, calico printing, etc.

Manufacture. The processes vary considerably, according to whether the raw material be rice, potato, or maize. Potatoes are first cleansed by steeping and washing in cylinders with special contrivances to remove stones. They are then reduced to pulp in special contrivances, provided with rapidly-revolving arms. In order to break up the cells and liberate the starch as completely as possible, a machine, known as a *rasper*, is frequently employed. The potatoes pass into a hollow cylinder provided with saw-blades on the inner surface. The cylinder is also fitted with a rapidly revolving shaft, carrying fork-shaped scoops, which pick up the potatoes and press them against the saw-blades, while water driven through the cylinder carries away the pulp with it. This pulp consists of starch granules, with a certain proportion of fibre, and the latter is separated by running the pulp through cylindrical wire gauze sieves of different mesh, so as to retain the coarser particles, while the starch granules suspended in water (starch milk) collect in large vats, where further separation of sand and heavy impurities is effected by stirring up and running off the starch milk. The liquors pass to settling vats or inclined planes, where most of the water is removed, the remainder being separated by filtration or by the aid of the centrifuge.

Rice Starch. Rice contains as much as 80 per cent. of starch, but its separation is difficult, as it is intimately bound up with the gluten. It is necessary to have resource to a chemical treatment. The rice is macerated for twenty-four hours with weak caustic alkali, 200 gr. to the gallon, and, after running off the alkali, is well washed. It is then ground in suitable machinery, and the flour passed through sieves, the coarser particles being returned to the mill for further reduction. The flour is then subjected to a second alkaline treatment, under the same conditions as before, and finally separated from impurities by subsidence and passage through silk sieves.

Wheat Starch. The whole corn is first steeped in water till soft, then crushed, and the liquor allowed to ferment. The action of the ferment is similar to the alkali used in the preparation of rice starch. Wheat was formerly much used for preparing starch, but for manufacturing purposes it has been replaced by cheaper substitutes.

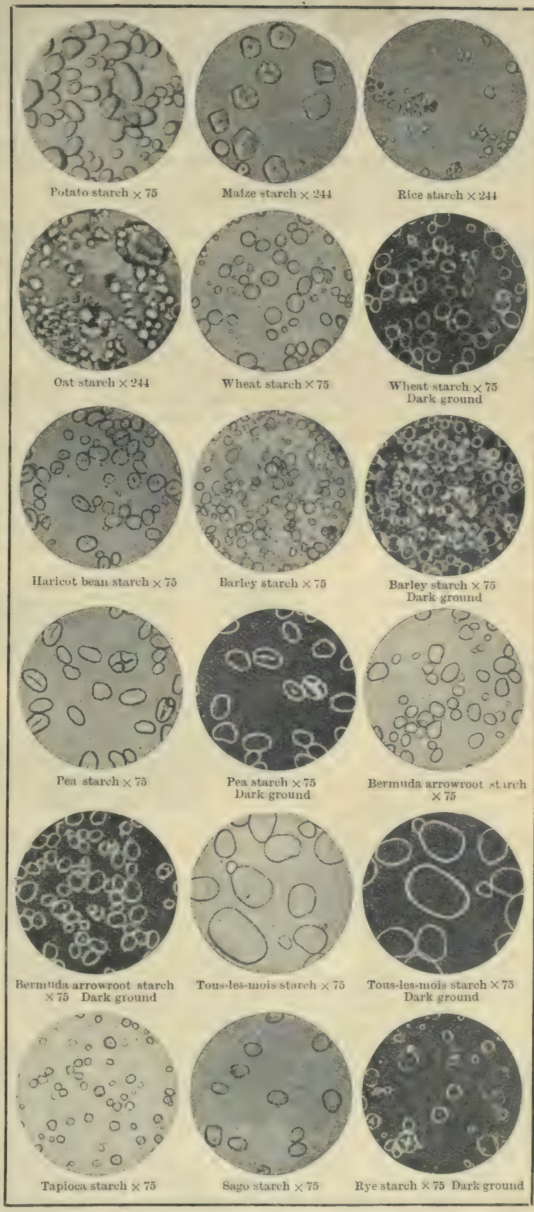
Maize Starch. The manufacture of maize starch is very complicated, as the by-products consisting of the gluten germ and oil serve for cattle foods and other purposes. The process consists in steeping, followed by rolling and threshing, much of the starch liquor being separated at this stage by means of rubber-rolled wringers called "slop machines." The remaining semi-dry mass is treated in "germ separators," somewhat on the lines of a washer and stoner [see Milling, page 3078]. In the starch liquor, 8·5° Bé., the shells sink while the germ floats and is separated, the oil expressed, and the cake used for cattle foods. The plant used is described in that section. The starch liquors are run through metal gauze sieves, called "shakers," to remove germs, and the starch is separated in cone settlers or on starch tables. The dried starch, containing now some 10 per cent. of moisture, is ground in roller mills and passed through silk bolting machines.

Glucose. Strong starch liquors, 24° Bé., are pumped into copper cylinders or "converters," where they are heated with 1 per cent. of concentrated hydrochloric acid for twelve minutes at 35 lb. pressure. The starch liquors, now converted into glucose, are almost neutralised with soda ash, and the coagulated gluten, etc., allowed to settle out. The clear liquors are filtered through bone-black to decolorise them, and concentrated in vacuum pans. Glucose is much used in the manufacture of beer, aerated waters, syrups, and jams.

Starch Granules. The general appearance of starch is familiar to most people. The fine white powder is tasteless, odourless, and has a harsh feel when rubbed between the fingers. It is insoluble in water and unaffected by ordinary atmospheric conditions. When, however, a few grains are put under the microscope they are seen to have a very definite and characteristic structure, presenting the appearance of rounded or angular cells of varying shape and size, according to their origin. These granules consist of little sacks of inert starch, cellulose protecting the more reactive "granulose" or pure starch matter within. In the preceding sections [see Acids and Alkalies, pages 4625 and 4770] mention has been made of starch paste, which gives a characteristic blue colour, with even traces of iodine, but very little reaction is obtained with raw starch granules, as they are protected by the outer skin of cellulose. It is necessary to rupture this skin in order to free the granulose, which is easily effected by treatment with boiling water. The granules swell up and ultimately burst, so that on allowing the liquid to stand, the empty skins sink to the bottom, leaving a clear solution of the granulose above. The different starches vary in the ease with which they gelatinise, some starch granules bursting at a

lower temperature than others. According to Lintner, potato starch is the most sensitive to heat, gelatinising at 65° C. Maize starch comes next at 75°, and the others at 80° or 85° C. These data account for some of the differences observed in the industrial applications of starch. The properties of the paste or solution of granulose varies a good deal, not only with the nature of the starch, but with individual specimens.

Microscopical Examination. As stated above, starch granules from different sources vary in appearance, and supply a means of identifying and distinguishing between the different varieties. The illustrations [11], which are reproductions of actual photomicrographs taken by Mr. Galt, will make this clear. For full detailed information the student is referred to his work on the "Microscopy of the More Commonly Occurring Starches," published by Baillière, Tindall & Cox, to whom we are indebted for permission to reproduce these illustrations. The photomicrographs are taken either by transmitted light, or on a dark ground. The translucency and general appearance are best shown by the former method, the outline and general shape of the granules by the latter. The magnifications are either 75 or 244 times the natural size, as will be seen from the subjoined list. The granulose in the interior is built up in layers, and some of the granules of potato and arrowroot show concentric markings which, although faint, are very characteristic. In addition, most starches possess a "hilum," or mark in the form of a spot or cross, the appearance and position of which is characteristic for each particular starch, thus the hilum of pea starch is slit shaped, in maize stellate, in Bermuda arrowroot near the broad end, and so on. The starch grains vary greatly in shape; potato starch forms flattened ellipsoids—that is to say, like an egg somewhat flattened — while maize is polygonal in outline and almost flat. Wheat starch is lenticular — that is, disc-shaped — but thick in the middle and thinning away down to the edges. The size of the grains also varies considerably, as will be evident on comparing the photomicrographs and the magnification. Tous-les-mois, a variety of arrowroot, has the largest grains, while those of oat and rice are very small; the average diameter of the latter may be taken as $\frac{1}{250}$th mm.



Potato starch × 75 | Maize starch × 244 | Rice starch × 244
Oat starch × 244 | Wheat starch × 75 | Wheat starch × 75 Dark ground
Haricot bean starch × 75 | Barley starch × 75 | Barley starch × 75 Dark ground
Pea starch × 75 | Pea starch × 75 Dark ground | Bermuda arrowroot starch × 75
Bermuda arrowroot starch × 75 Dark ground | Tous-les-mois starch × 75 | Tous-les-mois starch × 75 Dark ground
Tapioca starch × 75 | Sago starch × 75 | Rye starch × 75 Dark ground

11. PHOTOMICROGRAPHS OF STARCH (Galt)

INKS

The use of inks dates from the times of the earlier civilisations, such as that of the Egyptians, and the ink on some papyrus documents is as black to-day as ever it was. The Chinese, too, invented ink centuries before Christ, but it was probably in the third century of our era that the so-called Indian ink—more correctly Chinese or Japanese ink—was introduced.

Pigments for Ink. Inks may be classed according to their nature and mode of manufacture and use. In the first place it is convenient to distinguish writing ink from printing ink, in addition to which there are miscellaneous inks, such as marking inks, copying inks, typewriting inks, sympathetic inks, stylographic inks, and many others. In the writing inks, the colouring matter or pigment is suspended or dissolved in an aqueous liquor, while the printing inks are prepared from colour ground up with oil and lithographic varnish.

Almost any colouring matter or pigment may be used in the manufacture of ink, but only some of them are really suitable for the purpose, and the

object for which the ink is intended must also be considered. By far the great majority of inks used are black, or almost so, and with these there can be no question as to what should guide us in our choice of pigments. For documents and permanent records the writing or printed matter must be permanent, and must not fade when exposed to the light and air. This at once excludes most colouring matters and the coal-tar dyes, which are not sufficiently permanent for our purpose.

For printing inks, lampblack or finely-powdered carbon is the material almost universally employed, and it is also the basis of Indian ink. In the former case, the vehicle used is oil and varnish; in the latter a little glue and water.

Chemistry of Writing Ink. Writing inks, on the other hand, depend on the formation of tannate of iron in the paper. The permanent colouring matter is not contained in the ink as used, but gradually develops as the writing dries on the surface of the paper. At first glance this rather curious statement seems open to question, as we are familiar with inks with black or blue-black colour already developed. A short excursion into the realms of chemistry will be necessary to make this matter clear.

Writing inks may be prepared by mixing solutions of ferrous sulphate (copperas) with tannic acid. The former dissolves in water to a very pale green fluid; the latter, if pure, yields an almost colourless solution. Let us imagine for the time being that we are working with chemically pure substances. On mixing solutions of the two ingredients together, an almost colourless solution is produced which will contain ferrous iron in combination with tannic acid (ferrous tannate). Exposed to the air, however, it soon begins to darken and deposit a black substance; it gets thick, and as an ink would soon be of no use at all. The ferrous iron from the copperas is rapidly oxidised to ferric iron [see CHEMISTRY], and the black insoluble deposit formed is ferric iron in combination with tannin (ferric tannate). If previous to mixing the solutions of ferrous sulphate and tannic acid a little sulphuric acid be added to the former, the oxidation of the ferrous tannate is hindered, and the mixture will keep for a long time comparatively clear from deposit. The amount of sulphuric acid added need be only very small. When notepaper is written on with this ink, the acid is neutralised by minerals or other basic constituents in the paper, and is so weakened that it is no longer capable of hindering the oxidation of the ferrous tannate, and the black insoluble matter is deposited in the course of a few hours. Note, too, that it is deposited not only *on*, but *in* the paper, as the wet ink has time to soak in some distance before the oxidation process is complete. It would, however, be extremely inconvenient to write with colourless or almost colourless liquid; hence in the technical manufacture of inks an addition of indigo, aniline dye or logwood extract as a "provisional" colouring matter is made, which, with certain natural colouring matters contained in commercial tannin extracts, gives to the ink the colour we are accustomed to see. This colour is not permanent, but gradually fades on exposure to light and air, but the black iron tannate deposited in the paper is remarkably permanent. Its formation may be noted by comparing the colour of writing in blue-black ink just drying with what has been written the day before; the latter is much the blacker.

Tannins. Tannin or tannic acid is a substance widely distributed in nature and contained in the extracts from a number of plants. Some tannins are not suitable for ink-making. These are the "iron greening" tannins, such as are derived from hemlock, pine, kino, catechu, etc., which all give a green precipitate with iron salts. On the other hand, the "iron bluing" tannins, which give a blue precipitate with iron salts, and also as a general rule with potassium chromate, can all be used for making ink. These two classes of tannins probably differ from one another in chemical constitution, as on heating to 160° C the "iron greening" tannins yield catechol and the "iron bluing" pyrogallol; on these reactions is based a chemical test for distinguishing between them.

Raw Materials. Black inks—that is to say, inks which dry black—may be prepared from extracts of any vegetable substance, such as myrobalans, sumach, valonia or divi-divi, which contain iron bluing tannins; but the common materials are galls, and the particular tannin they contain is known as *gallo-tannic* acid. When acted upon by weak acids or certain moulds, gallotannic acid is converted into gallic acid, a chemically simpler substance, which goes further in making the same amount of ink. It is, therefore, used in the manufacture of the so-called gallic acid inks. Galls reach this country from the Syrian coast, and are commonly known as Turkey or Aleppo galls [12]. The female insect or gall wasp pierces the gall after a time, and escapes. Such galls show small holes, and are known as *white galls.* They contain less tannin than the unpierced galls, and consequently are worth less. A good sample of Aleppo galls will contain 60 per cent. or more of tannin.

12. ALEPPO (TURKEY) GALLS

The common English oakapple gall contains much less—16 to 20 per cent. tannin.

Chinese galls [13] are largely used on the Continent. They are produced by the Chinese aphis, and collected before the insect escapes, and contain 75 per cent. to 80 per cent. of gallotannic acid. Similar to the Chinese is the Japanese gall, which, however, contains less tannin. The chemist has several methods of measuring the amount of tannin in these products, and is therefore able to form a reliable estimate of the value of any particular material for ink-making.

Formulas for Ink. For every part of ferrous sulphate an infusion of about three parts of galls has been found to produce the best effect. There are innumerable recipes, dating from the time of Elizabeth. We will cite one or two.

Galls (1 lb.) extracted twice with 3 pints of boiling water, and the extract (2 quarts) mixed with 3½ oz. ferrous sulphate, and the same quantity of gum (Reid).

To prepare gallic acid ink, expose a decoction of 1 lb. galls to the air for 10 days, with continual daily shaking, and then add to each quart of the liquid 3½ pints of water, 9 oz. of ferrous sulphate, and 9 oz. of gum (Reid). Small quantities of "provisional colours," such as indigo or logwood extract, may be added.

The following is a standard ink of great permanency, the official standard record ink of the Commonwealth of Massachusetts, U.S.A., designed for use on State records. It is based on the formula of Schluttig and Neumann. We strongly urge its adoption in this country for similar purposes.

Tannic acid	23·4	parts
Gallic acid	7·7	,,
Ferrous sulphate	30·0	,,
Gum Arabic	10·0	,,
"Dilute" hydrochloric acid	25·0	,,
Phenol	1·0	,,

Each of the ingredients of quality prescribed by U.S.A. Pharmacopœia. Make up to 1,000 parts with water at 60° F.

What is Good Writing Ink? The following requirements are given by Mitchell and Hepworth:

1. It must yield permanent writing, which becomes black within the course of a few days.

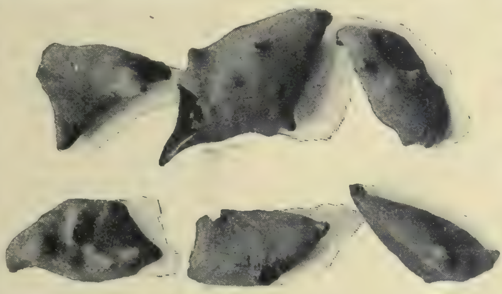
2. It must flow readily from the pen and penetrate well into the fibres of the paper without passing right through the paper.

3. It must not gelatinise or become mouldy in the ink-pots.

4. It should have a minimum corrosive action on steel pens.

5. The writing must not be sticky.

The permanence of the writing is determined by exposure to bright sunlight for some time, a comparative test being made with a piece of the same writing kept in the dark. The effect of chemicals may also be tried. In testing the penetrating power it is, of course, necessary to use a standard paper. The extent to which different papers are sized varies enormously.



13. CHINESE GALLS

Inks are conveniently contrasted with a standard, for which purpose the standard ink may be taken whose composition has already been given.

Printing Inks. These consist of lampblack or other finely powdered pigment, incorporated with boiled oil or varnish. In the preparation of these latter, linseed oil is heated in a cauldron, and kept stirred. This causes the oil to thicken gradually, so that it can be drawn out into strings. The older makers heated the oil till it was on the point of taking fire; the source of heat was then removed, and the oil set fire to and kept continually stirred, the flame being extinguished by a cover, and the oil tested from time to time until the desired consistency was obtained. Savage prepared six quarts of "burnt" oil in this manner, and then stirred in 6 lb. of resin and 1¾ lb. of soap. The varnish, while still hot, was incorporated with the pigment, consisting of Prussian blue and lampblack. The preparation of burnt oil was an operation requiring the greatest care. Nowadays, the oil is not ignited, but air may be blown in, and certain chemical substances known as "dryers" are added, which facilitate the thickening of the oil. The operation is also carried out at a lower temperature than would be necessary without dryers [see also PAINTS AND POLISHES, page 5041].

As to the black pigments, all varieties of carbon blacks are used, according to the quality of the ink. For a description of the different pigments and machines for incorporation and grinding, see Paints and Polishes; also a carbon black obtained from coal-tar, which is described in that section.

Coloured Inks. These are prepared very largely from coal-tar dyes, and it is now possible to produce ink of any desired tint or shade. Synthetic dyes have mostly replaced the vegetable colours previously used, besides which they are not nearly so costly. Their chief drawback is their want of permanence, especially on exposure to light and air. For the ordinary red writing inks the common dye eosine is generally used, the strength required being from 50 to 80 parts of water to one part of dye-stuff. It is unnecessary to use any gum or sugar, as such inks are perfectly fluid without such addition. Coloured printing inks are of increasing importance in consequence of the development of the three-colour and other processes. The more permanent mineral pigments are used where possible for reproducing coloured plates; but for certain colours, especially transparent colours in three-colour printing, nothing can replace certain of the aniline dyes, which are sufficiently permanent if carefully selected.

Copying and Typewriting Ink. Aniline dyes are generally used for copying inks, and invariably for typewriting inks, which are made so that they will copy. It is true that an ordinary writing ink will yield copies if taken at once, but if left over till the next day the ink will have oxidised and become fixed in the paper, and only the faintest copy will be procurable. Copying inks may be prepared according to the formulas for writing inks by suitable modification. They are rendered capable of being copied by the addition of such substances as gum, sugar, and glycerin in suitable proportions.

Miscellaneous Inks. Inks for rubber stamp pads are made from a suitable dye dissolved in a mixture of water 10 parts, acetic acid 10 parts, alcohol 10 parts, and glycerin 70 parts. Marking inks are usually metallic compounds, a metal, or some compound of the metal, being deposited on the fibre of the cloth, so that the writing will not wash out. For this purpose silver salts are suitable, a common method being to use a mixture of silver nitrate and tartaric acid or other substance, so as to form an easily reducible salt of silver. On passing a hot iron over the writing, the metallic silver is deposited. The following proportions are given by Dietrich: A solution of 25 parts silver nitrate, 15 parts gum, 60 parts ammonia solution, and two parts of lampblack or indigo, as a provisional colour.

Continued

ITALIAN—FRENCH—ESPERANTO—GREEK

Italian by F. de Feo; French by Louis A. Barbé, B.A.; Esperanto by Harald Clegg; Greek by G. K. Hibbert, M.A.

ITALIAN

Continued from page 5227

By Francesco de Feo

PREPOSITIONS—continued

Meanings of Simple Prepositions

THE number of simple prepositions being very limited, every preposition is used to indicate different relations, as will be easily seen from the following examples:

Di. The preposition *di* is used to show the following relations:

1. MANNER—*Lo faccio di buona vòglia,* I do it willingly; *La sua lèttera mi è stata di gran sollievo,* Your letter has been of great comfort to me.
2. POSSESSION—*La casa di mio zio,* my uncle's house; *l'orològio di suo padre,* your father's watch.
3. PLACE—*L'università di Napoli,* the university of Naples.
4. ORIGIN—*Egli nacque di pòvera gente,* He was born of poor people.
5. CAUSE—*Mi dispiace di averle fatto male,* I am sorry to have hurt you.
6. MATTER—*Cappello di pàglia,* a straw hat; *panno di lana,* woollen cloth.
7. DENOMINATION—*La città di Londra,* the city of London.
8. MEASURE—*Un muro di tre metri,* a wall three metres high.
9. OBJECT—*Si parlava di lei,* We were speaking of you.
10. SUBJECT—*Il canto dell'usignuolo,* the song of the nightingale.
11. QUALITY—*Qualche cosa di buono,* something good.

Di is also used with adjectives and participles, which in English require the preposition *with,* as: *Un uomo contento del suo proprio stato,* a man contented *with* his own state; *Un àlbero càrico di frutta,* a tree loaded with fruit.

A. The preposition *a* is used to show the following relations:

1. MANNER—*a brandelli,* torn to pieces; *a memòria,* by heart.
2. TIME—*Vi leverete alle otto,* You shall get up at eight.
3. PLACE—*Vado a Parigi,* I am going to Paris.
4. DIRECTION—*A mezzogiorno, al sud,* towards the south.
5. DIRECTION OF ACTION—*Parlo a voi,* I am speaking to you.
6. PRICE—*L'ho comprato a una lira e l'ho venduto a due,* I bought it at one franc, and I have sold it at two.
7. OBJECT—*Amore allo studio,* love of study.

Da. The preposition *da* is used to show the following relations:

1. ORIGIN—*Arnaldo da Brèscia; San Francesco d'Assisi; La maggiòr parte dei guai provèngono dall'ignoranza,* Most troubles come from ignorance.
2. COMPLEMENT OF AGENT—*Amato da tutti,* loved by everyone.
3. TIME—*Sto a Londra da due anni,* I have been in London these two years.
4. USE—*Sala da pranzo,* dining-room; *carta da lettere,* writing paper.
5. QUALITY—*Vestito da donna,* female attire.
6. PLACE—*Vengo dalla città,* I come from the city; *dal libràio,* at the bookseller's; *Venite da me,* Come to me (to my house).

Da me, da te, da lui, da noi, etc., = to my house, to your house, to his house, to our house, etc. (Compare the French: *chez moi, chez toi,* etc.)

Da me, da te, da noi, etc., are used also as simple reciprocals: *L'ho fatto da me,* I did it myself—*i.e.,* without any assistance. (Compare the English, "by myself," etc.)

In. The preposition *in* is used to show the following relations:

1. MANNER—*Scrivete in lèttere: dieci sterline,* Write in letters: ten pounds.
2. TIME—*In quindici giorni,* in a fortnight; *in un' ora,* in an hour.
3. PLACE—*Egli è in Inghilterra,* He is in England; *Mio padre vive in campagna,* My father lives in the country.
4. OBJECT—*Ho fidùcia in lei,* I trust you.
5. MATTER—*Una stàtua in marmo, in bronzo,* a statue of marble, of bronze.
6. AIM—*Festa in onore di San Francesco,* a feast in honour of St. Francis.

Con. The preposition *con* is used to show the following relations:

1. MANNER—*Quella signora canta con molta gràzia,* That lady sings with much grace; *La pòvera donna rispose con le làcrime agli occhi,* The poor woman answered with tears in her eyes.
2. COMPANY AND COMBINATION—*Carlo era in giardino con suo fratello,* Charles was in the garden with your brother; *fràgole con crema,* strawberries with cream.
3. MEANS—*Andremo col battello,* We shall go by boat.
4. CAUSE—*Con questa nèbbia non si può vedère,* With this fog one cannot see.
5. INSTRUMENT—*Egli scrive sempre con penne d'oca,* He always writes with quill pens; *Lo tagli con il coltello,* Cut it with the knife.

Per. The preposition *per* is used to show the following relations:

1. TIME—*Devo esser fuori per le sette,* I must be out by seven.
2. PLACE—*Siamo venuti per mare,* We have come by sea.
3. CAUSE—*Tutto questo è accaduto per la tua indifferenza,* All this has happened through your indifference; *Molti giovani si rovìnano per il gioco,* Many young men ruin themselves by gambling.
4. DIRECTION—*Il treno per Roma è partito,* The train for Rome has gone.
5. INCLINATION—*Questo ragazzo ha una passione per la pittura,* This boy has a passion for painting.
6. PRICE—*L'ho venduto per cinque lire,* I have sold it for five francs.

7. Means—*Le spedisco i libri per pacco postale,* I am sending you the books by parcel post.

8. Purpose—*Mio figlio sta facendo dei risparmi per comprare un automòbile,* My son is saving some money to buy a motor-car; *Viàggio per divertirmi,* I travel to amuse myself.

9. Distribution—*I ragazzi hanno avuto due soldi per uno,* The boys have had a penny each.

10. Concession—*Per cattivo che un uomo sia, avrà sempre qualche buona qualità,* Howsoever bad a man may be, he always has some good quality.

11. Imagined Quality—*Mi prese per un francese,* He took me for a Frenchman.

Esercìzio di Lettura—continued

Questa parola fece venìr le fiamme sul viso del frate: il quale però, col sembiante di chi inghiottisce una medicina molto amara, riprese: "lei non crede che un tal tìtolo mi si convenga. Lei sente in cuor suo che il passo ch'io fo ora qui non è nè vile nè spregèvole. M'ascolti, signòr don Rodrigo; e vòglia il cielo che non venga un giorno in cui si penta di non avermi ascoltato. Non voglia mèttere la sua gloria . . . qual gloria, signòr don Rodrigo! qual glòria dinanzi agli uòmini! E dinanzi a Dio? Lei può molto quaggiù; ma . . . ."

"Sa lei," disse don Rodrigo, interrompendolo con istizza, ma non senza qualche raccaprìccio[1], "sa lei che, quando mi viene lo schiribizzo[2] di sentire una prèdica, so benìssimo andare in chiesa, come fanno gli altri? Ma in casa mia! Oh," e continuò, con un sorriso forzato di scherno: "lei mi tratta da più di quel che sono. Il predicatore in casa! Non l'hanno che i prìncipi."

"E quel Dio che chiede conto ai prìncipi della parola che fa loro sentire, nelle loro regge; quel Dio che le usa ora un tratto di misericòrdia, mandando un suo ministro, indegno e miseràbile, ma un suo ministro, a pregàr per una innocente. . . ."

"In somma, padre," disse don Rodrigo, facendo atto d'andàrsene, "io non so quel che lei vòglia dire: non capisco altro se non che ci dev' èssere qualche fanciulla che le preme molto[3]. Vada a far le sue confidenze a chi le piace; e non si prenda la libertà d'infastidìr[4] più a lungo un gentiluomo." (*Continued*).

Notes: 1. fright; 2. whim; 3. in whom you are much interested; 4. to annoy.

IRREGULAR VERBS

Second Conjugation—continued

Verbs in **ĕre** (short)—continued:

Erigere, to erect

Past. Def.—Eressi, eresse, erèssero
Past Part.—Eretto

Espellere, to expel

Past Def.—Espulsi, espulse, espùlsero
Past Part.—Espulso

Esprimere, to express

Past Def.—Espressi, espresse, esprèssero
Past Part.—Espresso

Estinguere, to extinguish

Past Def.—Estinsi, estinse, estìnsero
Past Part.—Estinto

Figgere, to fix

Past Def.—Fissi, fisse, fìssero
Past Part.—Fisso
Conjugate like *fìggere:*
Affìggere, to stick; *prefìggere,* to prefix; *crocifìggere,* to crucify.

The following compounds of *fìggere* end in the past participle in *itto*: *confìggere,* to fix with nails, (*Past Part.—confitto*); *trafìggere,* to pierce (*Past Part.—trafitto*); *sconfìggere,* to defeat (*Past Part.—sconfitto*).

Also *fìggere* may have the form *fitto* for the past participle.

Fingere, to feign

Past Def.—Finsi, finse, fìnsero
Past Part.—Finto

Frangere, to break

Past Def.—Fransi, franse, frànsero
Past Part.—Franto
Conjugate like *fràngere*: *infràngere,* to infract

Friggere, to fry

Past Def.—Frissi, frisse, frìssero
Past Part.—Fritto

Giungere, to arrive

Past Def.—Giunsi, giunse, giùnsero
Past Part.—Giunto
Conjugate like *giùngere*: *soggiùngere,* to reply; *aggiùngere,* to add; *congiùngere,* to join; *raggiùngere,* to overtake.

Immergere, to immerge

Past Def.—Immersi, immerse, immèrsero
Past Part.—Immerso
Conjugate like *immèrgere*: *emèrgere,* to emerge

Imprimere, to impress, to print

Past Def.—Impressi, impresse, imprèssero
Past Part.—Impresso

Indurre (*indùcere*), to induce [see *addùrre,* page 5081].

Infliggere, to inflict

Past Def.—Inflissi, inflisse, inflìssero
Past Part.—Inflitto

Leggere, to read

Past Def.—Lessi, lesse, lèssero
Past Part.—Letto
Conjugate like *lèggere*: *elèggere,* to elect

Mettere, to put

Past Def.—Misi (*messi*), *mise* (*messe*), *mìsero* (*mèssero*)
Past Part.—Messo
Conjugate like *mèttere*: *ammèttere,* to admit; *dimèttersi,* to discontinue; *commèttere,* to commit; *comprométtere,* to compromise; *dismèttere, smettere,* to leave off; *immèttere,* to insert; *intromèttere,* to place between; *frammèttere,* to interpose; *permèttere,* to permit; *promèttere,* to promise; *rimèttere,* to postpone; *scommèttere,* to bet; *sottomèttere,* to submit; *premèttere,* to premise.

Mungere, to milk

Past Def.—Munsi, munse, mùnsero
Past Part.—Munto

Muovere, to move

Past Def.—Mossi, mosse, mòssero
Conjugate like *muòvere*: *rimuòvere,* to remove; *commuòvere,* to move; *promuòvere,* to promote

Opprimere, to oppress [see *imprimere* above].

Percuotere, to percuss

Past Def.—Percossi, percosse, percòssero
Past Part.—Percosso

Piangere, to weep

Past Def.—Piansi, pianse, piànsero
Past Part.—Pianto
Conjugate like *piàngere*: *rimpiàngere,* to regret

Porgere, to hand, to offer
Past Def.—Porsi, porse, pòrsero
Past Part.—Pòrto (unused)

Porre (*pònere*), to put
Ind. Pres.—Pongo, poni, pone, poniamo, ponete, pòngono
Past Def.—Posi, ponesti, pose, ponemmo, poneste, pòsero
Future—Porrò, porrai, etc.
Imperat.—Poni, ponga, poniamo, ponete, pòngano
Subj. Pres.—Pongo, ponga, etc.
Condit.—Porrei, porresti, etc.
Past Part.—Posto

Conjugate like *pòrre: suppòrre,* to suppose; *compòrre,* to compose; *decompòrre,* to decompose; *depòrre,* to attest; *dispòrre,* to dispose; *indispòrre,* to indispose; *espòrre,* to expose; *frappòrre,* to interpose; *oppòrre,* to oppose; *presuppòrre,* to presuppose; *propòrre,* to propose; *sottopòrre,* to submit; *sovrappòrre,* to put upon; *predispòrre,* to predispose.

Exercise LI.

1. Dopo solo due ore di combattimento, il nemico fu completamente sconfitto. 2. Il treno di Parigi è giunto con quaranta minuti di ritardo. 3. Le due rive del fiume sono congiunte da un ponte di legno. 4. Il signor B. è stato eletto deputato con ottocento voti su mille. 5. Dove avete messo il mio ritratto? 6. Sembra che abbiate pianto, cosa è accaduto? 7. Non avrei mai supposto una cosa sìmile. 8. Se avete letto il libro che vi prestai, restituìtemelo. 9. Scommetto che questa volta perderete. 10. Ho promesso a mio padre di èssere più diligente ed egli mi ha permesso di uscire.

Conversazione

Quando ha deciso di partire, questa settimana o l'altra?
Secondo (*that depends*), non so precisamente.
Dov' è la galleria Umberto I.?
Dirimpetto al teatro San Carlo.
Con chi era ieri sera al Caffè?
Ero con un signore americano, che àbita dirimpetto a noi.
Dove va? (*where are you going?*) Segga vicino a me, non mi lasci qui solo solo.
Non ho tempo; ho lezione alle dieci e mezzo.
Prende lezione tutti i giorni?
Sì, eccetto il giovedì.
Cosa n'è di quel tipo che prendeva lezione insieme con lei?
Non l'ho più visto; credo che sia ritornato in Germània.

Key to Exercise XLIX.

1. You will never learn anything, because you always play during the lesson. 2. Instead of one hundred francs we have received only fifty. 3. The villa of which I have spoken to you is on the other side of the Thames. 4. We have been obliged to postpone our departure till Monday for want of money. 5. If you are cold, sit near the fire. 6. Opposite to us there is a house to let. 7. Take care, my hat is there; do not sit on it. 8. Except these two, all the other pictures are worth nothing. 9. Let us speak openly, there must be no mysteries between us. 10. I will do it for your sake. 11. More than forty people remained buried under the ruins.

Key to Exercise L.

1. A good tree produces good fruit. 2. When I untie the parcel, you may choose what you like best. 3. What have you chosen? 4. The petition was signed by nearly one hundred persons. 5. My brother has written me a long letter. 6. If Mr. M. had not protected you, you would not now occupy this place. 7. The poor child is crying because she has pricked her finger with a needle. 8. Press the button to call the waiter.

Continued

FRENCH

Continued from page 5229

By Louis A. Barbé, B.A.

SYNTAX—THE ARTICLE

The Definite Article. 1. The definite article is required before all nouns used in their widest sense—that is to say, in a way that includes all the individuals or objects of a given class: *Les métaux sont plus utiles aux hommes que les diamants et les pierreries,* Metals are more useful to men than diamonds and precious stones.

2. In accordance with this principle (*a*) abstract nouns, and (*b*) nouns indicating material take the definite article: *L'hypocrisie est un hommage que le vice rend à la vertu,* Hypocrisy is a homage that vice pays to virtue. *Le platine est plus pesant que l'or,* Platinum is heavier than gold.

Exception: Sometimes an abstract noun and a preposition are equivalent to an adverb, and a noun of material and a preposition to an adjective; in such cases, no article is used: *Travaillez avec modération pour travailler longtemps,* Work with moderation so as to work long; *On dit qu'Henri II. fut le premier qui porta des bas de soie,* It is said that Henry II. was the first to wear silk stockings.

3. When one individual is taken to represent a whole class, the definite article is required: *Dieu dit ensuite: Faisons l'homme à notre image et à notre ressemblance,* Then God said: Let us make man in our image and likeness.

4. Titles immediately preceding proper nouns require the definite article: *Le règne de la reine Victoria en est un des plus longs de l'histoire; il est moins long cependant que celui du roi Louis XIV.,* Queen Victoria's reign is one of the longest in history; it is shorter, however, than that of King Louis XIV.

5. The article is used, in familiar language, before such words as *ami, homme, mère,* in addressing a person whose name is not known: *Ohé! l'ami, venez ici,* Hallo! friend, come here.

6. When proper nouns are qualified by an adjective, that adjective must be preceded by the definite article: *La pâleur du petit Pierrot inquiétait fort la vieille Marguerite,* Little Pierrot's pallor greatly troubled old Margaret.

7. The definite article is sometimes prefixed to the names of individuals to indicate familiarity, celebrity, or notoriety. With regard to men, this is almost exclusively limited to famous Italian writers and painters: *Le Pulci, le Bojardo, l'Arioste,* &c. The article is sometimes used in speaking of certain women widely known, either for good or for evil: thus, *la* Champmeslé, a famous actress; *la* Brinvilliers, a notorious poisoner.

8. The definite article is used with names of seasons and feasts, except Easter and, usually, Christmas: *le printemps,* spring; *le vendredi*

saint, Good Friday. In many cases, the feminine article *la* is used in connection with a masculine saint's name, the feminine word *fête* being understood: *la Saint-Jean*, St. John's (mid-summer) day: *Astronomiquement, l'automne est l'espace de temps du vingt septembre au vingt et un décembre*, Astronomically, autumn is the space of time from the 20th of September to the 21st of December; *La Pentecôte se célèbre cinquante jours après Pâques*, Pentecost is celebrated fifty days after Easter.

9. Days of the week take the definite article (*a*) when they are immediately followed by a date, or (*b*) to indicate a day set apart for the regular recurrence of some action: *Les États généraux se réunirent à Versailles le mardi cinq mai*, 1789, The States General met at Versailles, Tuesday, 5th of May, 1789; *Il se repose le lundi de n'avoir rien fait le dimanche*, He rests on Mondays for having done nothing on Sundays.

Exception: The days of "last week" and "next week" take no article: *Il est parti samedi dernier et il doit revenir jeudi prochain*, He left last Saturday, and he is to return next Thursday.

10. The definite article is used in the "absolute construction"—that is to say, before a noun not governed by any word in the sentence: *Nous apercevions les grenadiers, l'arme haute, l'œil gauche attaché sur nous, le droit caché par le fusil élevé*, We perceived the grenadiers, with levelled muskets, the left eye fixed upon us, the right hidden by the raised gun.

11. The definite article, with the preposition *à*, is used to express some peculiarity or distinctive feature: *Il y avait parmi les passagers, de jeunes Anglaises aux brillantes spirales de cheveux blonds*, There were amongst the passengers some young English girls with brilliant coils of fair hair.

12. In descriptions of personal appearance, the verb *avoir* and a noun with a definite article are frequently used: *Elle a les cheveux blonds, les yeux bleus, le teint frais, les dents blanches, et les lèvres vermeilles*, She has fair hair, blue eyes, a fresh complexion, white teeth, and ruddy lips.

13. The definite article is used in connection with *vers* or *sur* in expressions of approximate time: *Il est sorti vers le midi; il rentrera sur les six heures*, He went out about noon; he will come back about six.

14. The definite article is used distributively to express measure and weight: *Ce vin coûte deux francs la bouteille*, This wine costs two francs a bottle.

NOTE: In expressions of time, the preposition *par* is used instead of the article: *Son traitement est de huit cents francs par mois*, His salary is 800 francs a month.

15. The definite article is used before the names of continents, countries, and provinces: *La Suisse, la Belgique, le Danemark et le Portugal ne sont pas au nombre des grandes puissances de l'Europe*; Switzerland, Belgium, Denmark and Portugal are not amongst the great powers of Europe.

Exception: After the preposition *de*, the definite article is not used when it is intended to form an adjective phrase only: *La plupart des vins de France sont moins forts que ceux d'Espagne et de Portugal*; The greater part of French wines are less strong than those of Spain and of Portugal.

16. The definite article is used with the names of mountains, seas, and rivers: *Le Vésuve, célèbre volcan d'Italie, a onze cent quatre ving-dix mètres de hauteur*, Vesuvius, a celebrated volcano in Italy, is eleven hundred and ninety metres high.

17. With feminine names of countries, "in" and "into" are expressed by *en* without the definite article. The article is also omitted, and the preposition *de* used alone, after verbs expressing coming from those countries, such as *arriver de, venir de*, etc.: *S'il part d'Amérique le vingt-trois juin, il arrivera en Europe vers le premier juillet*, If he leaves America on the 23rd of June, he will arrive in Europe about the 1st of July.

18. The definite article is not used before numerals denoting the order of succession of sovereigns, etc. It is also omitted before nouns in apposition: *Louis seize, petit-fils et successeur de Louis quinze, monta sur le trône en* 1774, Louis the Sixteenth, the grandson and successor of Louis the Fifteenth, ascended the throne in 1774.

19. The definite article is not used in French, as it is in English, when a comparative is repeated:

Plus vous serez gai, plus longtemps vous vivrez, The gayer you are, the longer you will live.

Translation

[Words which have already been used, and words which are either identical or very similar in the two languages, are not given in the vocabularies.]

actuel, actual, present-day, modern
ajouter, to add
Allemagne (f.), Germany
allemand, German
Angleterre (f.), England
anglais, English
appartenir, to belong
appoint (m.), balance
bas-breton, low Breton
basque, Basque
Basses-Pyrénées (f.), Lower Pyrenees
Belgique (f.), Belgium
Bretagne (f.), Brittany
catalan, Catalonian
chiffre (m.), figure
comprendre, to comprise, understand
conserver, to retain
enfin, lastly
étendre (*s'*), to extend
étranger (*à l'*), abroad
flamand, Flemish
habitant (m.), inhabitant
hors de, outside of
idiome (m.), dialect, speech
Îles Normandes (f.), Channel Islands
Île Maurice (f.), Island of Mauritius
joindre, to join, add
langue (f.), tongue, language
normand, Norman
part (*à*), apart, special
quant à, as to, with regard to
répartir, to divide
revanche (*en*), by way of compensation
Suisse (f.), Switzerland
sur, on, out of

GÉOGRAPHIE DE LA LANGUE FRANÇAISE

La langue française comprend tout le domaine de la France actuelle, à l'exception d'une seule province, la Bretagne, où un million d'habitants sur un million huit cent mille parlent une langue connue sous le nom de bas-breton et qui est d'origine celtique. A cette exception importante, on peut encore ajouter trois petits groupes: le département du Nord, où deux cent mille habitants (sur un million deux cent mille) parlent la langue flamande, qui est d'origine allemande; le département des Basses-Pyrénées, où cent vingt mille habitants parlent le basque, idiome fort ancien, dont l'origine est inconnue; enfin le département des Pyrénées-Orientales (ancienne province de Roussillon), où cent trente mille habitants parlent la langue catalane, qui est dérivée du latin.

Si le domaine de la langue française ne s'étend pas sur tout le territoire actuel de la France, en revanche elle comprend à l'étranger plusieurs territoires importants, représentant un peu plus de trois millions

six cent mille habitants, ainsi répartis ; pour la Belgique un million six cent mille habitants ; pour l'empire d'Allemagne un million (Alsace-Lorraine) ; pour la Suisse française quatre cent mille ; enfin soixante mille pour les Îles Normandes, qui appartiennent à l'Angleterre.

A ces chiffres il faut ajouter, hors d'Europe, les colonies anglaises du Canada et de l'Ile Maurice, qui ont conservé l'usage du français, sans parler de nos propres colonies (Algérie, Guyane, Sénégal, etc.). C'est un appoint d'un peu plus d'un million cinq cent mille habitants à joindre au domaine linguistique français. (AUGUSTE E. BRACHET.)

The Indefinite Article. 1. The indefinite article is required in French, though not necessary in English, before an abstract noun used partitively and qualified by an adjective. *Ils ont supporté toutes les fatigues et toutes les privations avec une constance admirable,* They bore every fatigue and every privation with admirable constancy.

2. The indefinite article is not used after *quel,* what, nor after *sans,* without : *Quelle foule de maux l'ambition traîne à sa suite,* What a multitude of evils ambition drags in its train. *Je ne puis écrire sans plume,* I cannot write without a pen.

3. The indefinite article is usually omitted before a noun preceded by *jamais,* never: *Jamais homme n'a eu plus de succès avec aussi peu de mérite,* Never has a man had more success with so little merit.

4. The indefinite article is not used before nouns in apposition : *Nelson, célèbre amiral anglais, naquit en* 1758, Nelson, a famous English admiral, was born in 1758.

5. The indefinite article, though used in English, is omitted in French before nouns serving as predicative complements to such verbs as *être,* to be ; *devenir,* to become ; and *paraître,* to seem ; and also before nouns serving as the second accusative after such verbs as *faire,* to make ; *se faire,* to become ; *se montrer,* to show oneself ; *nommer,* to appoint ; *croire,* to believe : *Le père du maréchal Ney était tonnelier,* Marshal Ney's father was a cooper. *Montrez-vous bon ami,* Show yourself a good friend.

6. When *comme,* "as," means "in the capacity of," the noun that follows it does not take the indefinite article. The indefinite article is required before the noun following *comme* if that noun is the subject of a verb understood : *Ney fit les deux premières campagnes de la Révolution comme aide de camp,* Ney went through the first two campaigns of the Revolution as aide-de-camp. *Le pauvre vieillard se laissait tromper comme un enfant,* The poor old man allowed himself to be deceived like a child.

7. No indefinite article is required after fractional numbers : *Il a mis un quart d'heure à écrire une demi-page,* He has taken a quarter of an hour to write half a page.

The Partitive Article. 1. The partitive article *du, de la, des* is used regularly before any noun indicating a certain portion of any thing or a limited number of objects, whether the English equivalents "some" and "any" be expressed or only understood : *J'ai passé des jours heureux à la campagne,* I have spent (some) happy days in the country.

2. Before a noun preceded by an adjective, the preposition *de* alone is to be used : *De riantes prairies s'offraient à nos regards charmés,* Smiling meadows presented themselves to our delighted gaze.

3. If the adjective and the noun are so closely connected as practically to constitute a single word, whether joined by a hyphen or not, the article is to be used as well as *de* : *Il y a des belles-mères qui valent de véritables mères,* There are step-mothers who are as good as real mothers.

4. When a noun taken partitively is the object of a negative sentence, *de* alone is to be used : *Je n'ai pas d'argent,* I have not any money.

5. In English negative sentences, the indefinite article frequently has the meaning of "any," and must accordingly be translated by *de* : *Il ne porte jamais de chapeau,* He never wears a hat.

6. Before an adjective the partitive article is used to indicate distinction or opposition. Thus, *Donnez-moi de bon pain* means simply, Give me some good bread ; but, *Donnez-moi du bon pain* means, "Give me some of the good bread"—that is to say, there are two kinds of bread, good and bad, I want some of the good kind.

7. In negative sentences, the definite article is to be used before the complement, if that complement is followed by an adjective or an adjective clause. Thus, *Je n'ai pas d'argent* means I have no money ; but, *Je n'ai pas de l'argent pour le dépenser follement,* I have no money to spend extravagantly, implies that I have money, but that it is not to be squandered.

8. In a negative-interrogative sentence, the use of the partitive implies that an affirmative answer is expected. Thus, *N'avez-vous pas d'amis à Paris ?* Have you no friends in Paris ? is a genuine question, asked in order to obtain information. On the contrary, *N'avez-vous pas des amis à Paris ?* implies a belief, or even an assertion, that there are such friends, and may be translated, You have friends in Paris, have you not ?

9. The partitive article, or the preposition *de* standing instead of it, may be used after any preposition except *de* : *Avec de la patience et de la persévérance tout est possible,* With patience and perseverance everything is possible.

Place of the Article. 1. The article precedes the noun, but an adjective, a numeral, or *quelques,* meaning "few," may occur between it and the noun : *Le célèbre satirique Pope était bossu,* The celebrated satirist Pope was a hunchback. *Je ne regrette pas les quelques francs que cela m'a coûté,* I do not regret the few francs which that has cost me.

2. *Tout* (*toute, tous, toutes*) is the only adjective which, when accompanied by an article, always precedes it : *Il a perdu toute l'affection qu'il avait pour moi,* He has lost all the affection which he had for me.

3. The adjective *feu,* late (deceased) may either precede or follow the article. When it precedes it, there is but the one form for both genders : *La feue reine était aimée et respectée de tous ses sujets,* The late queen was loved and respected by all her subjects. *Ma mère est née la même année que feu la reine Victoria,* My mother was born in the same year as the late Queen Victoria.

KEY TO EXERCISE XXXVII.

1. Le paresseux travaille malgré lui.
2. Le soleil luit pour tout le monde.
3. Travaillez avec zèle : le travail est la source de l'abondance et de la joie.

4. L'invention du téléphone est due à Graham Bell et celle du phonographe à Edison.
5. De Calais quand le temps est clair, vous apercevez Douvres vis-à-vis de vous.
6. Apprenez que suivant le dire d'un ancien, il faut manger pour vivre et non pas vivre pour manger.
7. Ecrivez les injures sur le sable et les bienfaits sur l'airain.
8. Je crains Dieu, et, après Dieu, je crains principalement ceux qui ne le craignent pas.
9. Il faut tâcher de bien vivre avec tout le monde.
10. Il travaille toute la semaine excepté le dimanche.
11. Un enfant bien élevé ne doit rien faire malgré ses parents.
12. Les vacances commenceront dans moins de deux mois.
13. Votre oncle ne sait peut-être pas où est notre maison ; allez au-devant de lui et amenez-le si vous le voyez.
14. Un des romans de Jules Verne a pour titre, "Le Tour du Monde en quatre-vingts Jours."
15. Mettons-nous sous cet arbre, nous y serons à l'abri de la pluie.
16. Il dut la vie à la clémence et à la magnanimité du vainqueur.
17. Remplissez vos devoirs envers Dieu, envers vos parents et envers la patrie.
18. On trouve les mêmes préjugés en Europe, en Afrique et jusqu'en Amérique.

KEY TO EXERCISE XXXVIII.

1. La charité est patiente, douce et bienfaisante.
2. La boussole n'a point été trouvée par un marin ni le télescope par un astronome.
3. Ni l'or ni la grandeur ne nous rendent heureux.
4. L'homme n'est malheureux que parce qu'il est méchant.
5. Obéis si tu veux qu'on t'obéisse un jour.
6. Les hirondelles partent dès que les premiers froids arrivent.
7. On ne croit plus un enfant quand il a menti.
8. Si l'eau bout plus tôt sur les hautes montagnes, c'est parce que la pression de l'air y est moins forte.
9. Tous les hommes sont mortels ; or, vous êtes un homme ; donc vous êtes mortel.
10. S'il vient en France et qu'il passe par Paris, je serai charmé de le voir.
11. La terre ne s'épuise jamais pourvu qu'on sache la cultiver.
12. Conduisez-vous de telle sorte que tout le monde soit content de vous.

Continued

ESPERANTO
Continued from page 5232

By Harald Clegg

THE ACCUSATIVE

Motion. As has been shown [page 4655] the prepositions govern the nominative case, but when motion is indicated, it sometimes happens that the preposition used does not sufficiently contain all that is necessary to show the full extent of the movement, which may be either physical or moral. If we say "The bird flew under the table," it is not clear whether we mean that the bird, being there, flew about under the table or that it flew there from outside. To express the latter idea, however, Esperanto uses the accusative, even though there is a preposition before *tablo*, and thus indicates movement. The prepositions *al* (to) *ĝis* (up to, as far as), and *tra* (through) containing in themselves the full idea of motion, do not, in such cases, require the use of the accusative.

The following sentences illustrate the peculiar use of the accusative of direction.

En la mondon venis nova sento, Into the world a new feeling has come.

Mi saltis sur la muro, I jumped on the wall (I was there).

Mi saltis sur la muron, I jumped upon the wall (from elsewhere).

La lampo pendas super la tablo, The lamp hangs above the table.

Mi ĵetis la ŝtonon super la domon, I threw the stone above the house.

Li vojaĝis trans la maron, ĉar trans la maro li havis amikojn, He travelled across the sea, as across the sea he had friends.

Mi verŝis la inkon en la tason, kaj nun la inko restas en la taso, I tilted the ink into the cup, and now the ink remains in the cup.

This accusative of direction must, in similar circumstances, be applied to adverbs. Example:

La ŝtono falis teren, The stone fell to earth.

Nun, ni iros hejmen, Now we will go home.

Antaŭen! Forward! To the front!

Accusative Instead of Preposition. It is customary with intransitive verbs, when ideas of direction, time, price, weight, or measure are expressed, to omit the preposition and straightaway adopt the accusative, as in the following phrases:

Mi iras Berlinon, I am going to Berlin.

Mi restos tie tri semajnojn, I shall stay there three weeks.

Mi alvenos tie prokiman lundon, la 10an de Majo, I shall arrive there next Monday, the 10th of May.

La tablo estas longa dudek futojn ; ĝi pezas du cent funtojn kaj kostas naŭdek ŝilingojn, The table is twenty feet long ; it weighs two hundred pounds, and costs ninety shillings.

In all cases similar to the above, the accusative can, however, be dropped, and a suitable preposition be found.

PREFIXES

The remaining prefixes are as follow:

Ek denotes the beginning of an action or its momentary duration. Example:

Dormi, sleep ; *Ekdormi*, fall asleep.

Krii, cry ; *Ekkrii*, cry out suddenly.

Ge denotes the inclusion of both sexes. Example:

Frato, brother ; *gefratoj*, brother (s) and sister (s).

Mastro, master ; *gemastroj*, masters (s) and mistress (es).

Note that the use of *ge* always requires the plural.

Re denotes that an action is repeated or returned once. Example:

Sendi, send ; *resendi*, send back, return.

Trovi, find ; *retrovi*, recover, retrieve.

VOCABULARY

akompan', accompany
April', April
Aŭgust', August
atent', attentive
av', grandfather
buŝ', month
buter', butter
cerb', brain, mind
Decembr', December
dors', back
eduk', educate, rear
ekster, outside
Februar', February
festen', banquet
fianĉ', fiancé
fid', trust
fin', end
fiŝ', fish
flat', flatter
fluid', liquid (adj.)
foli', leaf, sheet
gast', guest
genu', knee
glat', smooth
griz', grey
Januar', January
Juli', July
Jun', June
ĵur', swear, vow
konsol', comfort, console
konvink', convince
Maj', May
Mart', March
nep', grandson
nev', nephew
Novembr', November
nutr', feed, nourish
okcident', west
Oktobr', October
ordinar', ordinary
orient', orient
pec', *piece*
Septembr', September
sekv', follow
send', send
serĉ', search, look for
ter', earth, ground
terur', terrible
tomb', tomb, grave
trankvil', quiet, tranquil

Exercise IX.

A year has twelve months; July is the seventh. It has thirty-one days, and follows June. The remaining months are January, February, March, April, May, August, September, October, November, and, lastly, grey and dull December. Son and daughter. Brother and sister. Nephew and niece. Grandfather and grandmother. Man and woman. Mr. and Mrs. Fiancé and fiancée. He flatters himself, but he did not convince me. She burst out laughing. I begin to think that you wish to deceive me. My grandson sent the letter back to me. She wrote on a piece of paper. I looked for the butter, and finally found it under the newspaper. I fell on my knees, and swore that I had given back the money. In the morning (morningly) the sun is seen (one sees) in the east. In the evening (eveningly) it is in the west. The cage hangs on the wall outside the house. She quietly put the liquid back into the bottle. My cousins (*m.* and *f.*) fed the fishes. The leaf fell from the tree to the ground. He fell into the river. They accompanied him as far as the theatre. They endeavoured to comfort her, but could not. The best of us must die and return to earth through the grave. A terrible wind began to blow, and the clouds hid the sun.

Key to Exercise VIII.

Mi tre bedaŭras aŭdi pri la morto de via frato. Oni diras al mi ke vi ne fartas tiel bone hodiaŭ kiel hieraŭ. Kvankam la reĝo estas gracia kaj fortika, li estas fiera kaj tiel kruela, kiel la plej sovaĝa besto. Nia lando estas la plej kara kaj bela en la tuta mondo. Mi ne pensas ke mi estas ĵaluza, sed mi vere kredas ke ŝi adoras min pli ol vin. Ili komencis libere diskuti kaj disputi pri niaj metodoj, sed mi devas konfesi, ke mi ne povis esprimi mian aprobon. Ĉu vi povas direkti min al la teatro? Jes, sinjoro, kun plezuro (*or*, plezure). Jen ĝi estas, maldekstre. La suno, alta en la ĉielo, varme brilas. Mi estas ĝuste tiel laca kiel vi mem, sed ne tiel malĝentila. Li konstruis altan domon el ŝtono. Via ideo estas tre bona kaj interesa, sed ĝi estas neoportuna. En nia lando la popolo estas libera. Ili malfeliĉe perdis grandan nombron da amikoj. Mi miras, ke mi ne renkontis vin kaj viajn amikojn kune. Mi pardonis lin, sed li fiere foriris kaj fermis la pordon. Floroj kreskas dum la tuta jaro.

Continued

GREEK

By G. K. Hibbert, M.A.

Classical and Modern Greek

Greek is the language spoken by the Greek race. When we pass from the period of myth, or semi-myth, of which the poems of Homer are a record (before 850 B.C.), to the historic period, we find the Greek race divided into Dorians, Æolians, and Ionians, each speaking their own dialect. These dialects are called respectively Doric, Æolic, and Ionic. Classical Greek consists of that form of the Ionic dialect which was spoken in Athens during the period of her literary eminence (500 to 300 B.C.): it is called Attic, from Attica, the district in which Athens was situated. Modern Greek is very like the Greek of the classical period, and Demosthenes or Plato would be able to read without difficulty the newspapers now published in Athens. Few languages have had such a glorious history, and none other perhaps has so influenced the thought of the world.

At the outset, the student is recommended to procure a good Greek dictionary, and for general purposes Liddell and Scott's Abridged Greek-English Lexicon (Clarendon Press, price 7/6) cannot be improved upon.

The Alphabet. The Greek alphabet has twenty-four letters.

Name		Form		English equivalent
Alpha	Ἄλφα	Α	α	a
Beta	Βῆτα	Β	β	b
Gamma	Γάμμα	Γ	γ	g
Delta	Δέλτα	Δ	δ	d
Epsilon	Ἒψιλόν	Ε	ε	e (*short*)
Zeta	Ζῆτα	Ζ	ζ	z
Ēta	Ἦτα	Η	η	e (*long*)
Theta	Θῆτα	Θ	θ	th
Iota	Ἰῶτα	Ι	ι	i
Kappa	Κάππα	Κ	κ	k, *or hard* c
Lambda	Λάμβδα	Λ	λ	l
Mu	Μῦ	Μ	μ	m
Nu	Νῦ	Ν	ν	n
Xi	Ξῖ	Ξ	ξ	x
Omicron	Ὂμικρόν	Ο	ο	o (*short*)
Pi	Πῖ	Π	π	p
Rho	Ῥῶ	Ρ	ρ	r
Sigma	Σίγμα	Σ	σ, ς	s
Tau	Ταῦ	Τ	τ	t
Upsilon	Ὗψιλόν	Υ	υ	u *or* y
Phi	Φῖ	Φ	φ	ph
Chi	Χῖ	Χ	χ	kh
Psi	Ψῖ	Ψ	ψ	ps
Omega	Ὦμέγα	Ω	ω	o (*long*)

NOTES. 1. *Omicron* means literally "*little o*," and *Omega* means "*great o*."

2. With regard to *Sigma*, at the end of a word the form used is ς, elsewhere the form is σ—*e.g.* πίστις, pistis (faith).

3. The vowels are α, ε, η, ι, ο, ω, υ. Of these ε and ο are always short; η and ω always long; α, ι, υ sometimes long, sometimes short.

4. ξ, ψ, and ζ are *double* consonants, the first being composed of κ and σ, the second of π and σ (as in psalm), and the third of δ and σ.

Pronunciation. We have not a complete account of ancient Greek pronunciation, and there is no uniform standard of pronunciation of Greek in Great Britain and the United States. Some boldly adopt the "English" pronunciation, and sound the words exactly as they would be sounded in English. But the following system is far more correct, and may be adopted for all practical purposes:

Pronounce	Pronounce
α as *a* in *father*	ο as *o* in *not*
ε as *e* in *ten*	ω as *o* in *note*
η as *a* in *late*	υ as the French *u*.
ι as *i* in *machine*	

Pronounce the consonants as in English, except that γ before κ, ξ, χ, or another γ has the sound of *n* (ἄγγελος = *angelos*, messenger, angel); elsewhere γ is always hard.

θ is pronounced like *th* in *thin*, ζ like soft *ds* (not quite like the English *z*), and χ is always hard, like the German *ch*.

The diphthongs may be pronounced much as their English equivalents, except that αυ = *ou* in *house*, and ου = *ou* in *uncouth*.

Breathings. Every word that begins with a vowel or a diphthong has a "breathing" over the vowel or diphthong. The breathing is either *smooth* (᾿), like an apostrophe, or *rough* (῾)—*e.g.*: ἰχθύς = *ichthus*, fish; ὁδός = *hodos*, road. The rough breathing shows that the vowel is aspirated, while the smooth breathing shows that it is not aspirated.

A diphthong takes the breathing upon its *second* vowel—*e.g.*: αὐτός, υἱός (= *huios*, son).

When the consonant ρ (*r*) begins a word it is generally written with a rough breathing, ῥ—*e.g.*: ῥόμβος (rhombus), ῥόδον (rose), while ρρ in the middle of a word is generally written ῤῥ—*e.g.*: Πύῤῥος, Pyrrhus.

Punctuation Marks. Greek uses the *comma* and the *full-stop*, like English. It uses also a *colon*, a single point above the line (·), the equivalent of the English colon and semicolon. The mark of interrogation in Greek (;) is identical in form with the English semicolon.

Accents. The student will have noticed that every Greek word hitherto mentioned has an accent of some kind marked over it—*e.g.*: αὐτός, Βῆτα. (The accent is additional to the breathing in words beginning with a vowel.) The Greek system of accents is however rather complicated, and had better be treated later on. Meanwhile, the student can write his Greek without the accents, though taking care to put in the breathings correctly. The marks of accent were invented for the purpose of teaching foreigners the correct pronunciation of Greek.

EXERCISE I.

Write the following Greek words in English letters: ῥοδόδενδρον, διάγνωσις, ἄγκυρα, μεταμόρφωσις, καταστροφή, παντόμιμος, Ξέρξης, Σωκράτης, ψαλτήριον.

NOUNS

There are three declensions of nouns and adjectives, corresponding roughly to the first three declensions in Latin. The first is called the *A* declension, and the second the *O* declension. These two are the *Vowel* declensions, as opposed to the third, which contains all nouns not of the first or second, and is sometimes called the *Consonant* declension.

Nouns are declined for number and case; adjectives for number, gender, and case. The *numbers* are three: singular, dual, and plural. The dual is used to denote two objects, but its use is not frequent, and it is generally replaced by the plural.

The *genders* are three: masculine, feminine, and neuter. In Greek, as in Latin, the gender of a noun is often determined by its ending, not, as in English, by its meaning. Thus οἰκία (house), is feminine, although *house* is neuter in English. Names of males, however, are generally masculine, and names of females feminine. Most names of rivers, winds, and months are masculine; of countries, towns, trees, and islands, feminine, as also are most nouns denoting qualities or conditions—*i. e.*, abstract nouns.

The *Cases* are five:

	Answers the question:
1. *Nominative*	Who *or* what?
2. *Vocative*	(Case of the person addressed).
3. *Accusative*	Whom *or* what?
4. *Genitive*	Whose *or* whereof?
5. *Dative*	To, for, by, with whom, *or* what?

NOTES: 1. The Latin ablative is replaced in Greek by the genitive and dative.

2. The nominative and vocative plural are always alike.

3. In neuter nouns, the nominative, vocative, and accusative are alike in all numbers; and in the plural of neuter nouns these three cases always end in α.

4. The nominative, vocative, and accusative dual are always alike; and so are the genitive and dative dual.

First Declension Nouns: A STEMS. Masculine nouns of this declension end in ας or ης; and feminine nouns end in α or η.

The masculine nouns are declined like the two following: νεανίας (young man), πολίτης (citizen).

	Singular	
Nom.	νεανίας	πολίτης
Voc.	νεανία	πολῖτα
Acc.	νεανίαν	πολίτην
Gen.	νεανίου	πολίτου
Dat.	νεανίᾳ	πολίτῃ
	Dual	
Nom., Voc., Acc.	νεανία	πολίτα
Gen., Dat.	νεανίαιν	πολίταιν
	Plural	
Nom., Voc.	νεανίαι	πολῖται
Acc.	νεανίας	πολίτας
Gen.	νεανιῶν	πολιτῶν
Dat.	νεανίαις	πολίταις

NOTE. The little ι written under the last letter of the dative singular is called *iota subscript*. The dative originally ended in ι, as νεανίαι, πολίτηι ; but the ι is now always written below the other vowel.

Like one or other of the two nouns given above decline ταμίας, steward ; κριτής, judge ; ναύτης, sailor ; δεσπότης, master ; Πέρσης, a Persian ; γεωμέτρης, geometer ; and στρατιώτης, soldier.

Feminine nouns of this declension are declined like the four following : ψυχή (soul), οἰκία (house), χώρα (land), θάλασσα (sea).

	Singular			
Nom. / *Voc.*	ψυχή	οἰκία	χώρα	θάλασσα
Acc.	ψυχήν	οἰκίαν	χώραν	θάλασσαν
Gen.	ψυχῆς	οἰκίας	χώρας	θαλάσσης
Dat.	ψυχῇ	οἰκίᾳ	χώρᾳ	θαλάσσῃ
	Dual			
N., V., A.	ψυχά	οἰκία	χώρα	θαλάσσα
Gen. Dat.	ψυχαῖν	οἰκίαιν	χώραιν	θαλάσσαιν
	Plural			
Nom., Voc.	ψυχαί	οἰκίαι	χῶραι	θάλασσαι
Acc.	ψυχάς	οἰκίας	χώρας	θαλάσσας
Gen.	ψυχῶν	οἰκιῶν	χωρῶν	θαλασσῶν
Dat.	ψυχαῖς	οἰκίαις	χώραις	θαλάσσαις

NOTE. 1. Nouns ending in α preceded by ε, ι, or ρ, retain the α throughout the singular, and are declined like οἰκία or χώρα. Other nouns ending in α are declined like θάλασσα, unless the α is a contracted form of αα, as μνᾶ (*a mina*), contracted from μνάα (gen. μνᾶς, dat. μνᾷ).

2. The vocative of Ἑρμῆς (the god Hermes, or Mercury) is Ἑρμῆ, not Ἑρμα.

Second Declension Nouns : O STEMS. Masculine nouns of this declension mostly end in ος, neuters in ον. There are very few feminine nouns of this declension, and these few end in ος, like the masculine.

	Singular	
Nom.	λόγος (word)	δῶρον (gift)
Voc.	λόγε	δῶρον
Acc.	λόγον	δῶρον
Gen.	λόγου	δώρου
Dat.	λόγῳ	δώρῳ
	Dual	
Nom., Voc., Acc.	λόγω	δώρω
Gen., Dat.	λόγοιν	δώροιν
	Plural	
Nom., Voc.	λόγοι	δῶρα
Acc.	λόγους	δῶρα
Gen.	λόγων	δώρων
Dat.	λόγοις	δώροις

Like one or other of these, decline ἄνθρωπος, man ; νόμος, law ; κίνδυνος, danger ; πόταμος, river ; βίος, life ; θάνατος, death ; δοῦλος, slave ; ἵππος, horse ; πόλεμος, war ; στρατηγός, general ; διδάσκαλος, teacher ; ὁδός (f.), road ; νῆσος (f.), island ; σῦκον, fig ; ἱμάτιον, outer garment ; ζῷον, animal ; τόξον, bow ; and δένδρον, tree (except that dative plural is δένδρεσι). The vocative of Θεός, god, is Θεός. Many nouns in εος, οος, and οον of this declension are contracted. Thus νόος, mind (νοῦς) ; ὀστέον, bone (ὀστοῦν).

	Singular	
Nom.	νοῦς	ὀστοῦν
Voc.	νοῦ	ὀστοῦν
Acc.	νοῦν	ὀστοῦν
Gen.	νοῦ	ὀστοῦ
Dat.	νῷ	ὀστῷ
	Dual	
Nom., Voc., Acc.	νώ	ὀστώ
Gen., Dat.	νοῖν	ὀστοῖν
	Plural	
Nom., Voc.	νοῖ	ὀστᾶ
Acc.	νοῦς	ὀστᾶ
Gen.	νῶν	ὀστῶν
Dat.	νοῖς	ὀστοῖς

A few nouns of this declension end in ως (masculine and feminine) and ων (neuter). This is sometimes called the Attic declension. Thus νεώς, temple (masc.), and ἀνώγεων, hall (neuter).

	Singular	
Nom., Voc.	νεώς	ἀνώγεων
Acc.	νεών	ἀνώγεων
Gen.	νεώ	ἀνώγεω
Dat.	νεῴ	ἀνώγεῳ
	Dual	
Nom., Voc., Acc.	νεώ	ἀνώγεω
Gen., Dat.	νεῴν	ἀνώγεῳν
	Plural	
Nom., Voc.	νεῴ	ἀνώγεω
Acc.	νεώς	ἀνώγεω
Gen.	νεών	ἀνώγεων
Dat.	νεῴς	ἀνώγεῳς

THE ARTICLE

There is no indefinite article in Greek, but there is a definite article ὁ, *the*, which is declined as follows :

	Singular			Dual			Plural		
	Masc.	*Fem.*	*Neuter*	*Masc.*	*Fem.*	*Neuter*	*Masc.*	*Fem.*	*Neuter*
N.	ὁ	ἡ	τό	τώ	(τά)	τώ	οἱ	αἱ	τά
A.	τόν	τήν	τό	,,	,,	,,	τούς	τάς	τά
G.	τοῦ	τῆς	τοῦ	τοῖν	(ταῖν)	τοῖν	τῶν	τῶν	τῶν
D.	τῷ	τῇ	τῷ	,,	,,	,,	τοῖς	ταῖς	τοῖς

It will be noticed that the feminine is declined like an η noun of the first declension (ψυχή), and the masculine and neuter almost exactly like a masculine and a neuter noun of the second declension respectively (λόγος and δῶρον). The feminine dual forms τά and ταῖν (especially τά) are rare ; τώ and τοῖν are generally used for all genders. The definite article agrees with its noun in number, gender and case, as : ἡ κόρη, the girl ; τὰ ὀστᾶ, the bones ; ταῖς οἰκίαις, for the houses.

EXERCISE II.

Put into Greek : 1. Of the young man. 2. To the bones. 3. The sailor (accusative). 4. Of the two soldiers. 5. Of the law. 6. To the animal. 7. The rivers. 8. To the citizens. 9. Of the temple. 10. The fig (accusative). 11. Of the island. 12. The girls.

Continued

THE COMMERCIAL HIGHWAYS OF THE WORLD

The ocean route distances are given in *statute* miles (69 = 1°) instead of the more usual *nautical* miles, or knots (60 = 1°), so that they can be correctly compared with those of the trans-continental routes

NATURAL WEALTH OF NATIONS

A Survey of the Chief Natural Economic Regions of the World and their Place in the World's Commerce. India's Trade

Group 13
COMMERCIAL GEOGRAPHY
8

Continued from page 5308

By Dr. A. J. HERBERTSON and F. D. HERBERTSON

HAVING studied the distribution of the chief natural commodities we must now turn our attention to the economic conditions of different countries. Commerce depends on one person or people producing more than they want of something which another person or people do not produce, or produce in insufficient quantities. The excess or defect of production may be due to natural conditions or to the stage of economic development of a people. For instance, most plants are confined to a particular zone—cotton, sugar, and coffee to the warm, tropical and sub-tropical zone, oats to the cool temperate zone. Again, coal is exported from Britain to the Baltic because there is practically no coal quite near the Baltic coast; but coal is exported from Britain to China, not because there is no coal in China, but because the vast coalfields there have not yet been properly opened up. It will be useful, therefore, to consider how countries may be grouped according to their natural products, taking into consideration the economic conditions of their inhabitants.

Zones of Different Natural Products. The first broad distinctions are between the hot or tropical, the warm or sub-tropical, the cool or temperate, and the cold or Polar lands. In each belt varieties occur according as the rainfall is heavy, moderate, or very scanty. The natural vegetation gives the key to these different divisions, and the products of each type of forest, grassland, or desert are discussed in previous articles.

The Chief Trading Countries. In our own country, in most of Europe, North America, and European colonies, modern methods of cultivation, of transport and commerce have been introduced. Stock-raising, fishing and agriculture are carried on for the market, and the working of minerals and the development of manufactures are developed on a large scale. These countries may be further subdivided into two groups—those importing food and raw materials and exporting manufactured articles—such as Central and Western Europe and Eastern North America; and those largely exporting natural and cultivated products, and importing manufactured goods, such as Eastern Europe and European settlements in warm and cool temperate zones.

The Eastern Awakening. In Japan, China, and India, the soil is even more carefully cultivated than with us, but metal-working and manufacture by modern methods on a vast scale have only recently been introduced. The trade of these countries resembles that of the group last considered in that they still export natural products and import manufactures. The methods of agriculture are laborious, labour-saving machinery is little used, products are grown mainly for home use, manufactures and metal-working may be described as domestic, for the factory system has only recently been introduced. Japan is at present the most advanced of these countries, but India and China are following it.

The Poor Lands of the World. The poor lands around the Poles and the desert margins have too little natural wealth for exportation on a vast scale, but here and there, where rich mineral deposits occur, such as gold in Klondike, or where irrigation can be practised, as in Russian Central Asia, a dense and busy population is concentrated in districts usually of limited area. The lumber, etc., of the forest [pages 4657-8], and the animal wealth of the seas [page 5121] are the chief other commodities. The trade is one of export of natural products or minerals more or less worked up in exchange for manufactures.

The Rich Hot Lands. The rich grasslands of the hot belt have a denser population engaged in agriculture, pastoral pursuits, and even domestic manufacture. A considerable local trade is developed. Their exports are mainly natural products, for which manufactures are taken in exchange. They differ from the poor lands in possessing vast possibilities, and here and there, under European stimulus and supervision, are producing on a large scale—for example, bananas in the West Indies and cotton in most of the area.

The hot wet forests are much more backward. There is little agriculture or even domestic manufacture. The spontaneous products such as rubber, oil palm, coco-nuts are exported in exchange for light cloth, hardware, and firearms. In the distant future these forests may become invaluable sources of supply of vegetable foods and raw materials.

The Study of Economic Geography. The first question to ask in studying commercial geography is what are the natural conditions of a country, its vegetation, its animal products, its mineral wealth? Next come considerations of density of population—how far the country can support the people, how far routes are opened up to allow its districts to communicate with each other and with other lands. These points have already been dealt with in the general geography.

The next consideration is the commerce of the land—how far it has commodities to export, and how far it must obtain necessaries and luxuries from outside its boundaries. From the outset the student is strongly advised to make use of statistical publications. It is not necessary to remember the detailed figures, but it is important to grasp the relative importance of the different exports and imports, and to try to understand what they mean geographically.

In the following sections such statistical tables will be freely used at first, and their significance pointed out, so that the student may become familiar with the examination of such tables for the purposes of commercial geography. Later, when he is thoroughly practised in this, it will not be so necessary to print many tables, but merely to refer the student to them in such annuals as the "Statesman's Year Book," the "Daily Mail Year Book" or "Whitaker's Almanack."

It is easiest to begin with the simpler conditions of the lands last mentioned, and to end our survey with the economic activities of the complex modern states of European peoples and their descendants

Brazil as a Type of Tropical Lands. Let us select Brazil as one type of the hot, wet forest area with open woods in the higher lands, and also at lower elevations, where it lies farthest from the equator. In the "Statesman's Year Book" for 1906 the exports of Brazil are given as :

EXPORTS	Quantities.		Values.	
	1903.	1904.	1903.	1904.
	Bags.	Bags.	£	£
Coffee ..	12,927,239	10,024,536	19,076,277	19,957,569
	Kilos.	Kilos.		
India-rubber	31,712,288	31,863,491	9,733,041	11,219,393
Hides & skins	30,636,175	35,847,320	1,820,481	2,382,256
Cocoa ..	20,899,643	23,160,028	1,012,224	1,095,535
Yerba maté	36,129,555	43,757,003	676,684	954,360
Tobacco ..	23,397,705	23,961,255	948,867	838,516
Cotton ..	28,235,995	13,262,738	1,323,665	826,507
Other articles	—	—	2,291,936	2,139,422

These may be divided into spontaneous and cultivated products. The most important of the natural products are rubber from the great forest, which has merely to be collected. The savanas yield grass for cattle, hides and skins come from the pastoral higher lands, especially of the south. Brazil has, however, many plantations, the products of which are chiefly the alkaloid beverages—cocoa in the warm, wet parts of the north-east; coffee, mainly on the hills near the tropics, and yerba maté, or Paraguay tea, from the south. Finally, cotton, the fibre most used for clothing in the tropics, is grown in the north-east, but very little of it is manufactured in Brazil. [See also page 4288.] In exchange for these Brazil imports :

IMPORTS	1903.	1904.
	£	£
Cotton goods	3,794,641	3,851,826
Iron and steel work and machinery	2,924,472	3,328,397
Wheat and flour	2,351,373	2,837,713
Coal	1,215,352	1,270,654
Wine	1,453,357	1,579,392
Jerked beef	1,158,270	1,268,189
Woollens	648,347	661,752
Rice	726,589	613,461
Codfish	610,140	586,740

As Brazil has so few factories, these are mainly manufactured goods. The next important class consists of products of the temperate zone and fish for food. Lastly, there is coal.

The Congo Free State. The Congo Free State [see page 3583] is another example of a country with like geographical conditions, but somewhat different economic ones. Its exports are as follows :

Rubber, £1,738,858 ; ivory, £153,592 ; palm nuts and oil, £97,249 ; white copal, £57,027 ; cocoa, £12,957 ; coffee, £6,138.

Here is a land more recently opened to European influence. Spontaneous products of the forest play an all-important part, and cultivated plants yield but a small proportion of the total exports. The imports to the Congo are equally suggestive :

Tissues and clothing, £375,109 ; food and drink, £233,084 ; metals, machinery, and steamers, £138,549 ; arms and ammunition, £30,573.

Here the white man is even more dependent than in Brazil on supplies from Europe, whence practically all food and clothing are brought.

Typical Islands of the Hot Belt. Now let us take two islands where the systematic exploitation of the soil has progressed much further than in tropical Africa or South America. In Cuba, in the West Indies, the exports for 1904 were as follows:

Sugar, £11,510,588 ; tobacco, £5,199,538 ; fruits, grains, etc., £718,837 ; forest products, £384,938 ; mineral products, £299,413 ; animal products, including fish, £159,965.

Of these, sugar is by far the most important, finding a ready market in the United States. Tobacco, half as valuable as sugar, and in the form of Havana cigars, is sent all over the world, but especially to Europe and the United States.

In Java, in the East Indies, the chief exports are sugar, coffee, rice, tea, indigo, cinchona, tobacco and tin, all cultivated except the last-named.

In both islands cultivated products far outweigh spontaneous ones in importance.

Possible Products of the Intertropical Zone. We may take the products of these islands as typical of the kinds of commodities which may be expected to be produced in larger and larger quantities from this intertropical region. In return, textiles, especially cotton, machinery and hardware, and iron and steel goods of many kinds, luxuries of food and drink, especially wines, spirits and beer, are imported, mainly from Europe and North America, but also from Japan, and in the case of cotton, from India.

The commercial importance of this area may also be estimated by the population. The total number is comparatively small, and when we consider the stage of civilisation of large numbers of these people, we realise how small their powers of production and their demands for consumption must be.

Yet much land in the hot zone is fit for such cultivation as is practised in Cuba or Java or parts of Brazil. The total area of the hot belt is about half of the area of the globe. There are parts of this hot belt towards its margins, such as India and the south of China, which are well cultivated and densely peopled. The economic conditions of these old culture lands deserve a little closer study.

The Lands of Southern and Eastern Asia. The eastern monsoon lands are partly intertropical and partly subtropical. The more sparsely peopled mountainous areas of South-east Asia may be classed with the regions just described. India and China, however, with their dense populations, require further consideration. In both there are vast fertile lowlands, which receive periodic rains in summer. Much of these lowlands is flooded annually, so that a layer of fresh soil is left which repairs the loss of fertility due to the crops of the previous season. There is, however, a great climatic difference between the two. India is hot at all seasons. Most of China has a well-marked winter, which is particularly severe in the north. This limits the period of cultivation in Northern China, and excludes all crops which cannot stand frost or are not annuals. Let us examine more closely the economic conditions of India. Before doing so the student should read again the remarks on pages 2818-2822 and 2972.

Economic Regions of India and Ceylon. From an economic point of view we may divide India into the following districts: 1. The north-western mountainous land of Kashmir, producing wool. 2. The north-eastern mountainous land of the Eastern Himalayas and Assam, with many tea plantations on the mountain slopes and also with sal and other timber trees. Some rubber is collected in the lower Assam forest. 3. The irrigated Punjab, with wheat, millet, sugar-cane and some pulses. 4. The united provinces of Agra and Oudh, which form a transition from 3 to 5. 5. Bengal, the

wettest and most fertile of the northern lowlands, producing rice, sugar-cane, opium, indigo and jute in the deltaic region. 6. The Sind desert, with sheep, goats and camels, yielding wool and hair, and also cotton in irrigated places. 7. The Northern Deccan, with cotton, wheat, millet and oil-seeds. 8. The Central Deccan, with cotton, millet, oil-seeds, pulses and sugar-cane to the south in Mysore. 9. The west or Malabar coast, producing cotton in the lowlands, sugar in the north, in Kathiawar, and teak on the forested slopes. 10. The east or Coromandel coast, producing cotton, palmyra palm sugar, tobacco, in addition to millet, oil-seeds and ground nuts. 11. Ceylon, with coco-nut groves round the coast, rubber plantations and rice-fields on the lowlands, tea, cinchona, and cocoa on the hillsides, and rich plumbago or graphite mines. 12. Upper Burma with its teak forests and ruby mines. 13. Lower Burma, with rice fields, teak, and petroleum.

Exports of India. A very clear idea of the chief products of the different divisions of India may be obtained from the table given below, showing the value of the exports from the chief provinces.

Turn back to the descriptions of these divisions on pages 2818-22 and notice what physical features and climatic conditions control the distribution of these products. We are now able to form a picture of the great commercial movements from the producing centres to the ports.

VALUES OF EXPORTS IN THOUSANDS OF RUPEES

Division.	Rice.	Wheat.	Opium.	Indigo.	Cotton.	Seeds.
Sind	1,879	110,245	—	392	18,972	15,240
Bombay	4,200	25,530	30,402	661	120,315	69,480
Madras	11,099	—	—	1,685	25,363	13,091
Bengal	42,950	34,260	75,832	5,608	8,307	45,886
Burma	135,940	26	—	—	1,391	411

To Karachi, mainly by lines of the Indus basin, are sent wheat from the Punjab and some cotton and oil-seeds. Bombay receives from lines along the coast and descending from the Deccan the great supplies of cotton from Gujerat and the black cotton area of the plateau, whence come oil-seeds, opium, and wheat. It also exports cotton yarn and piece-goods from Bombay mills. The lines of the wider eastern coastal plains of the Northern Deccan converge on Madras, where cotton, oil-seeds, and rice from the easily-flooded deltaic lands are exported. The greatest port of India is Calcutta, with the immense fertile plains of the Ganges and the hilly lands of Assam as hinderland. Hither opium is brought for exportation to China, and great supplies of jute, jute manufactures, rice, oil-seeds and wheat. The plains of Burma furnish the rice and the hills the teak, which are exported at Rangoon.

The Total Trade of India. The overland trade of India is small owing to the mountain barrier, which makes communication difficult. The total sea-borne trade of India, excluding Government stores and treasures, was on the mean of the five years 1901-05: Imports, 1,090,000,000 rupees; exports and re-exports, 1,420,000,000 rupees; while in 1904-05 imports were nearly 1,300,000,000 rupees, and exports over 1,650,000,000 rupees, of which less than 34,000,000 were re-exports. The overland trade is less easy to estimate accurately, but in 1904-05 was over 70,000,000 rupees worth of goods imported and over 60,000,000 rupees worth exported, mainly from and to Nepal and Kashmir. (A rupee is worth 15·4d.). The import trade of India consists of cotton manufactured goods, which are worth over two-fifths of the whole and three times as much as articles of food and drinks, and of hardware, cutlery and metals, which are the next in importance. Machinery, railway plant, oils, clothing, and chemicals are other import items. The metals notably absent from exports are important among imports.

The Customers of India. From the above list it will be seen that at present the greater part of the imports can be supplied most easily from Europe, and that the exports, excluding opium to China, manufactures of cotton to China, Japan, and the East generally, and jute to wheat-growing lands as gunny bags, are products lacking in Europe. This is borne out by the table showing the origin of imports and destination of exports:

VALUES OF IMPORTS AND EXPORTS IN THOUSANDS OF RUPEES.—1904-5.

Country.	Imports into India.	Exports from India.	Total.
United Kingdom	630,594	424,306	1,054,800
China	19,231	194,319	213,550
German Empire	37,323	142,713	180,036
Belgium	35,202	83,868	119,070
France	18,052	95,448	113,500
United States ..	14,857	97,109	111,966
Japan	11,733	97,172	108,905
Straits Settlements	30,285	62,506	92,791
Austria-Hungary	40,083	46,603	86,686

We may ask the question, How far is this trade permanent? Obviously India can supply its people with food, but when the population is dense no food remains for export. For instance, Burma, with a far smaller fertile area, exports three times as much rice as Bengal, because the very large population of Bengal consumes most of the crop. Most of this Burmese rice goes to Japan and Straits Settlements. On the other hand, owing to the great demand for wheat in temperate lands, India produces much as a winter crop mainly for the foreign market, the cultivators living largely on millet. India has an advantage in sowing the wheat when the results of the northern temperate harvests are fairly well known. In 1904, when the North American crop failed, the export from India was 25,500,000 cwt. Famine, however, has to be reckoned with, and the above figures may be compared with the 6,100 cwt. of wheat exported to the United Kingdom in 1900. The increasing demand for raw cotton is likely to ensure an extension of cotton cultivation, while the proposed prohibition of opium smoking in China will greatly diminish the cultivation of the poppy.

India's poorness in minerals, especially in coal and iron in close proximity to each other, greatly hinders industrial development. The climate is unfavourable to great exertion in factories, and the quality of labour is not so good as at home. Hence, though wages are low, the cost of labour per yard is relatively high. For the present India will be a great exporter of foods and raw material and importer of manufactured goods and luxuries.

Ceylon. Colombo exports tea, coco-nuts, and graphite or plumbago. Rubber is being cultivated and will soon be important. Colombo is one of the great shipping junctions of the world, where ships from Suez in the north-west, the Bay of Bengal in the north-east, Singapore and the Far East, and Australia in the south-east, all meet.

Continued

Group 2 EARTHENWARE 3	# THE DECORATION OF POTTERY
POTTERY continued from page 5237	**How Decoration is Applied to Pottery. Clay Decoration. Printing on the Biscuit. Coloured Glazes. Chromo-Lithography. Lustres**

By MARK SOLON

THERE is no industry which lends itself to so many varied forms of decoration as pottery manufacture. At almost every change in the state of the clay opportunities are afforded for introducing colour and decoration. If we exclude the plastic property of the clay, which enables us to create new and decorative forms by the help of the modeller, there remain five distinct technical methods of decorating the ware. Taking these in the order in which they occur in the process of manufacture, they are: (1) colouring of bodies or clays; (2) introduction of colour on the biscuit either by printing or painting; (3) use of coloured glazes; (4) application of soft colours or enamels on the glaze; (5) metallic or lustre decoration. These methods used either singly or in combination with each other give us an endless field of decorative effects.

The Application of Colours. It is not necessary here to dwell upon the methods of the sculptor or modeller, which, although they contribute so much to the decoration of the pottery, must be considered as a separate art. We will, therefore, confine ourselves to the application and production of various colours.

These colours depend entirely on certain metals and their preparation and behaviour under different treatments. Those most commonly used are iron, cobalt, chromium, nickel, manganese, copper and antimony. The more expensive and rare metals, such as gold, silver, uranium, platinum, titanium, are used in small quantities to give certain effects.

Preparing Colours for Bodies or Clays. In preparing our colour for decoration with bodies or clays we are limited to those metals whose colouring properties will withstand the heat necessary to vitrify the clay, or, in other words, the temperature of the biscuit oven. In every case a small quantity of the suitably prepared metal or its salt is intimately mixed with the body, being introduced in the form of an extremely fine powder. The colours which can be obtained are roughly:

BLACK: Black generally results from a mixture of iron and manganese, preferably mixed with the marl or clay, which already naturally contains a quantity of oxide of iron. The colour is made richer and deeper by the addition of a small quantity of oxide of cobalt.

BLUE. Blue tints are derived from the oxide of cobalt mixed with a white body. The brighter or sky blues are obtained by calcining the cobalt with an excess of alumina before introducing into the body. Indigo tint is due to an excess of silica and the presence of zinc.

GREEN. The oxide of chrome mixed with a white body gives the foundation of all green tints. They may be made more blue by the addition of cobalt, or yellow by the introduction of iron or nickel oxide.

20. WEDGWOOD JASPER WARE

YELLOW. Yellow is due to the oxide of iron, and is generally produced by introducing marls which contain a quantity of the oxide. Lighter tints are sometimes made by mixing a small quantity of rhutile (titanate of iron) with the white body. This latter stain is more permanent, and will stand a higher temperature than the natural marls, which, after a certain heat, have a tendency to go grey.

BROWN. Brown is given by a mixture of chrome and iron, or the chemical combination of the two, chromate of iron, with a white body. If a natural marl containing iron be used, the tint may be obtained by the introduction of a small quantity of manganese.

RED. The dull reds are due to natural red marls in which the staining agent is iron.

Brighter tints may be obtained by mixing with a felspathic body a natural silicate of iron obtained from the South of France and known as "Grès de Thiviers," which, after calcination at a high heat, developes a bright red tint.

Clay Painting. All the above colours are applied to the clay piece before it becomes dry—that is, when it is sufficiently dry to withstand the brush. The painting in coloured bodies is known as *Barbottine painting.* Other decorations which might be included under this heading are the jasper ware of Wedgwood [20], in which the ornament in white or coloured clay is applied to pieces of a

different-coloured ground. Moulds having been prepared, either in plaster, pottery, or hard stone, of the ornament which has to appear on the piece, impressions are taken from them in clay in the white or coloured body. The ornament is then applied to the vase, the back of the clay impression being first of all moistened with thin slip. Marble or agate ware [21], in which a striated effect of various colours in imitation of these stones is required, is produced by roughly mixing together layers of different-coloured clays before the piece is pressed.

21. "AGATE WARE" TEAPOT

Sgraffito. Sgraffito [22] is a method of decorating in two colours. A layer of white or tinted clay is laid upon a body of darker colour. The lines and background of the ornament are made by scraping away the top layer of lighter clay, revealing the darker body underneath.

Colour Applied on the Biscuit, or Underglaze. The metals used in the process of decoration in which the colour is applied on the biscuit, or underglaze, are almost the same as those in the previous method. In the case of the black, blue, green and brown, the metals are the same. However, to reduce the strength of the stain, and in some cases to develop a particular tint, the metals are first of all calcined with other ingredients. For instance, the staining power of cobalt, which produces blue tints, considerably increases by calcining it first of all with such fluxes as zinc or baryta. The brighter tints, as has already been said, are produced by calcining it with an excess, about one to twenty, of alumina. The deep browns are produced from the pure chromate of iron. The lighter and redder tints are made by introducing an excess of alumina and zinc. Olive green is due to chrome oxide alone, calcined with an excess of china clay. Blue-greens are produced by mixtures of chrome, cobalt and zinc. Where a mere flux is required to lighten the tint of any particular colour, the mixtures already referred to are reduced with such materials as flint, stone, ground biscuit, or tin ash.

22. SGRAFFITO PLAQUE

Yellows are produced by calcining the oxide of antimony with oxide of lead.

Reds do not exist in underglaze decorations, the nearest colour being a bright crimson, which is obtained by a mixture of oxide of tin, whiting, and oxide of chrome. The metallic oxides, after having been intimately mixed with their fluxes and calcined, are finely ground in water, washed, and dried.

Printing. Printing from engraved copper plate is the most common form of underglaze decoration. The colour is mixed with linseed oil, which has previously been boiled until it has thickened. The copper plate is heated and charged with the mixed colour. After the superfluous colour has been scraped from the plate, a piece of thin paper, wet with soap size, is placed upon it, and the two put through a cylindrical press [23]. On pulling the paper from the plate it brings with it the colour left in the engraved lines. This is placed carefully upon the biscuit piece face downwards, and rubbed with a flannel rubber until the pattern is fairly transferred to the piece.

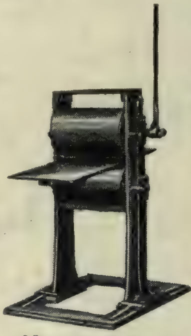
The Printing Machine. In some cases, especially where large quantities of one pattern are to be printed, machines are employed [24]. The machine consists of a copper cylinder, on the surface of which the pattern is engraved. The cylinder is made to revolve slowly, colour being fed upon it from a small open trough. The superfluous colour is scraped off with a flat steel knife, the edge of which fits closely against the surface of the copper. The paper, which is wound upon a large reel, is made to pass underneath the cylinder, meeting it at the point where the engraved lines only are charged with colour. The pattern is transferred to the paper by the pressure of a roller covered with indiarubber, which is brought to bear against the copper cylinder. In this way the paper bearing the pattern is delivered from the machine in a continuous band, which is cut as required and applied to the biscuit ware in the manner already explained. The pieces

are then put into the water, the paper washed off, leaving the engraved pattern on the biscuit.

The oil is then generally burnt out of the colour in small muffle kilns, and the piece dipped in the glaze and fired in the ordinary way.

When the decoration is painted, the medium mixed with the colour is either gum tragacanth or turpentine.

Coloured Glazes. Coloured glazes are produced by melting or mixing with the transparent glaze the metals already referred to. The composition of the glaze, however, varies the tints given by the different metals. For instance, cobalt, if mixed with glaze in which there is a preponderance of lead, develops a deep indigo tint; if with an excess of alkalies, such as soda and potash, it develops a much brighter colour. An excess of soda in the glaze with copper develops a turquoise blue, but if lead be in excess the copper gives a green tint. Potash with manganese gives a bright violet. Yellows are formed by the introduction of iron oxide in a lead or alkaline glaze, or from the chromate of lead. Reds are formed from the mixture of tin, whiting, and chrome already referred to, together with a soft lead glaze. The glazes may be painted on the biscuit, the ornament being defined by raised lines previously formed in the clay [25]. Without these lines the glazes on melting would have a tendency to mix with each other where they meet, and so make any definite form of ornament impossible. If varying shades of the same colour be required, modelled surfaces may be covered with coloured glaze, lighter or darker tints being produced according to the thickness of glaze accumulating in the depressions.



23. CYLINDRICAL PRINTING PRESS (W. Boulton, Ltd.)

Application of Soft Colours or Enamels. Up to the present our palette has been somewhat limited, owing to the heat necessary either for the firing of the clay or melting of the glaze. In the application of soft colours or enamels on the glaze, however, our range of colours is almost endless, as only a feeble heat is necessary to remelt them on the surface of the glaze, the base, or, as it is termed, the *flux*, with which metallic oxides are mixed being an extremely fusible lead or alkaline glass. In the majority of cases, a flux composed of lead, borax, and sand is used. This is melted like an ordinary frit, and afterwards ground or remelted with the colouring oxide. The metals, in order to reduce them to a fine state of division, are usually dissolved in hydrochloric acid, and then precipitated with carbonate of soda. They are afterwards well washed and dried.

The decoration is generally painted on the ware, the painter using turpentine and essence of lavender as a medium to carry the colour. Where great depth of colour is required, the pieces are fired sometimes three or four times, further tints being applied between each firing.

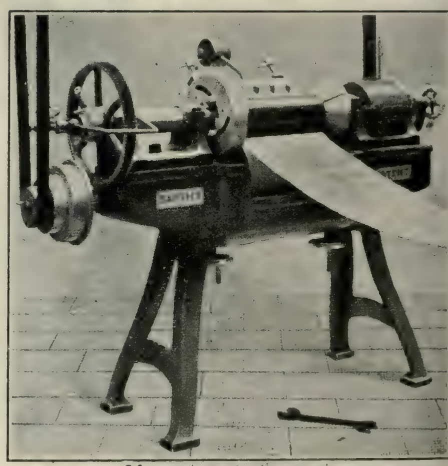
Chromo-lithography. Another form of decoration on glaze which in recent years has become extensively used is that of *chromo-lithography*. The lithographic stones are drawn and prepared in the usual way, but printed with ceramic colours on highly-varnished paper. Between the varnish and the paper is a thin layer of gum and dextrin. The lithographic transfer is placed face downwards upon the ware, which has been previously heated and sized with a preparation of resin. After being rubbed firmly to the ware the piece is put in water, when the gum and dextrin dissolve, allowing the paper to float away, and leaving the varnish and colours upon the glazed surface.

Gilding. The application of gold to the glazed surface is an important feature in the decoration of pottery. If used in combination with other processes, it is always the last stage of decoration, requiring only a very slight temperature to fix it to the glaze. The metallic gold is prepared by grinding it finely in water or turpentine, with mercury, silver, lampblack, gold alloy, and a small quantity of soft flux composed of lead, borax, and flint.

It is either pencilled, printed, or stippled with cotton-wool on to the ware. After firing, the gold, which presents a dull appearance, is scoured with fine sand and burnished with pieces of hard, highly-polished stone.

A cheaper form of gilding is by using the gold in the form of a lustre and known as "Liquid Gold." In this case the salt of the metal is intimately mixed with a large quantity of oils and resin so that the preparation contains only a small quantity of actual gold. It is brilliant after firing and so requires no scouring or burnishing.

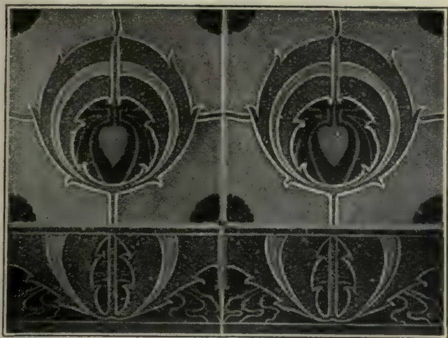
Firing Enamel Colours. All decorations on the glaze are fired, in order to fix them



24. PRINTING MACHINE (T. Smith & Son, Hanley)

to the surface of the piece, through muffle kilns. These kilns consist of fireclay boxes, generally about 3 ft. 6 in. wide, 7 ft. high, and 10 ft. long. They are built up of thin fireclay slabs, tongued and grooved on every side in such a way that the

joints between them do not allow any sulphurous or injurious fumes from the burning fuel to enter. Around the box are arranged a number of flues connected with the fire holes. The flame, on leaving the mouth, wraps round the kiln once, and sometimes twice, before escaping into the chimney. Figure **24** shows an elevation and end view of a muffle kiln, which is down-draught in principle. The pieces are placed inside the inner chamber on iron shelves built up with stout iron props of varying heights. The firing lasts from 10 to 12 hours, and the heat attained is from 900° to 1,000° C. The fireman gauges the heat of the kiln by drawing from it small pieces of pitcher, which have been coated with rose colour. This colour, which is prepared from a precipitate of gold and tin, varies accurately in tint with the increase of heat. The following table gives the degrees of heat at each variation in the tint of the colour:



25. TILES DECORATED WITH COLOURED GLAZES (Minton's, Ltd.)

Reddish brown	650° C.
Red	860° C.
Rose purple	900° C.
Violet rose	920° C.
Violet	950° C.
Pale violet	980° C.
Slight violet tint (rose colour destroyed)	1,000° C.

Lustre Decoration. Metals, such as gold, platinum, silver, uranium, copper, and iron, may be applied to the surface of the glaze, and by suitable preparation give an iridescent or lustrous effect to the glaze, after firing at a low heat. This is done by dissolving the metals in acid, and intimately mixing them with such substances as sulphur, essence of lavender, and other reducing agents, which tend during the firing to keep the metal in its metallic state. The method of preparing these lustres is one which requires great care and attention, the metallic salt being combined with reducing agents.

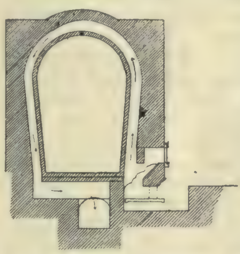
Preparing the Lustres. To prepare yellow lustre, for example, dissolve 30 parts of resin in a capsule resting in a sand bath, which has been gradually heated. When the resin is melted, add ittle by little 10 parts of nitrate of uranium, stirring constantly. While still stirring, add from 35 parts to 40 parts of essence of lavender. When this mixture has become thoroughly homogeneous by the constant stirring, remove the capsule from the sand bath, and add little by little a further 30 to 35 parts of essence of lavender. Allow to cool for several hours before using.

The other metals are prepared in a similar manner, the essence of lavender being sometimes replaced by turpentine or any other oil which does not precipitate the substances with which it is mixed. In the same way the resin may be replaced by sulphur or Canada balsam.

The lustre is pencilled upon the ware in thin coats, and fired in muffle kilns at a low heat.

Two Recent Productions. Some idea of the almost unlimited combinations of materials and treatment producing varied decorative effects can be formed from a short description of two recent productions, Rouge Flambé and Crystalline glazes [see Plate facing page 5233]. The former, which is essentially a "flame" red colour, is obtained by submitting a glaze containing copper and tin to reducing atmospheres—that is, during the melting of this glaze the atmosphere in the kiln is charged with unconsumed carbon generally by introducing coal gas without the necessary air to bring about its complete combustion. This change in atmosphere turns the copper from green to bright red.

Crystalline effects, which appear like clusters of opaque white or coloured stars floating in a transparent glaze, are produced by charging the glaze with an excess of some material (generally zinc) which has the property of separating out in crystalline formations as the molten glaze cools. The action is similar to that which takes place when salt has been added to excess in boiling water. While the water boils the salt appears in solution, but on cooling crystallises out on the sides of the vessel. Some of the examples shown in the plate are the productions of Messrs. Pilkington & Co., Ltd., and are the result of long research by the well-known ceramic chemist and author, Mr. William Burton. In the specimens A, E, F, H, J, L, Mr. Burton has successfully reproduced the achievements of the early Chinese potters.



26. SECTIONAL ELEVATION OF MUFFLE KILN
Arrows indicate the course of the flame

The other pieces shown on this plate, B, C, D, G, K, N, O, P, Q, R, S, are various Flambé effects by Messrs. Doulton & Co., Ltd., Burslem, and manufactured under the personal direction of Mr. Cuthbert Bailey, who has done much to make the production of Flambé a commercial success, and to systematise a process which up to recently has been greatly a matter of chance. Although the processes explained at the beginning of the article are those most generally used, the decorative potter may have recourse to an almost endless number of methods.

Continued

Group 3
SOCIOLOGY

12

Continued from page 5248

THINGS THAT LIVE FOR EVER

The Things that Make for Progress. Liberalism and Conservatism and their Relation to Progress. Necessity of Toleration and Freedom. Truth is Unconquerable

By Dr. C. W. SALEEBY

WE need waste no time upon those who declare that progress is a myth. The answer to this assertion in all its forms may be conveniently expressed in the one word "Darwin." The critic who does not know what that name stands for should play marbles. He may become efficient at that, but sociology is not for him. In these days we are able to go right on, and, recognising progress as the greatest of facts, to ask what are its laws and conditions. What is the meaning of the past to us?

We are the Product of the Past. In the first place, we are its products; we *are*, whereas, it only *was*; it has done its work, and from that point of view our business is not with it, but with its results. There has been far too much idle looking backwards, but if this course has taught us anything it is that we may look backwards not idly but wisely. We therefore turn deliberately backwards, but it is the future of which we think. To tell the story of the past evolution of man without any reference to what it signifies in the future is, as has well been said, to set out to tell a good story, and to leave out the point. We do not mean to leave out the point. In virtue chiefly of the work of Charles Darwin, work which we may associate with the year 1859, when he published one of the greatest books of all time, we know now that all kinds of animals and plants, small or great, highly organised, or lowly organised, owe their existence to the operation of certain factors, very easy to understand and explain. The terms we may recall are "the survival of the fittest" and "natural selection," which, however, is not a good term, for it does not explain itself.

What the Law of Progress is. Neither Darwin nor Spencer, who preceded him by a few years, nor Lamarck, nor Darwin's own grandfather, Erasmus Darwin, was the originator of the idea of organic evolution. We find it even amongst the Greeks, and we find it expressed six hundred years before Christ, by those two mighty contemporaries, Gautama, the Buddha, and Heracleitus, of Ephesus. Many people, thus, had said that organic evolution had occurred, this involving the proposition that progress had occurred, since no quibbling about the meaning of the word progress and no pessimism can explain away the difference between man and the worm. But none of Darwin's predecessors had clearly showed *why* organic evolution should have occurred, or given a practical instance of how it was occurring. Darwin established an epoch because he showed us the Law of Progress, practically illustrated in living nature. The theory, in brief, is this: that all kinds of animals and plants, high or low, large or small, tend to multiply at a very considerable rate, as we human beings do, and in fact all of the candidates for life. In the new generation some are better fitted for life in the environment in which they find themselves than are others, and as there is not room for all, there occurs a struggle for existence.

Nature is Cruel to be Kind. The struggle for existence among men, or the lower animals, or microbes, or anything you please, is easily explained. If there be room for only a proportion of the total, and if we individuals vary in our fitness, it is necessary that the fittest shall survive, whereas the weakest shall go to the wall. That, of course, credits Nature with a certain brutality. But if we come to consider what the result of the survival of the fittest is, we shall see that Nature is really cruel to be kind. Like tends to beget like; and the descendants of the unfit, whether of an oak, an ox, or a man, tend to resemble their parents in their unfitness. The descendants of unfit parents will tend to be like their parents and will also find the struggle for life hard. If, therefore, unfitness is allowed to propagate more unfitness, then life will be hard for all who are to come; while, on the other hand, fitness will tend to produce a fitter race. Hence the action of natural selection is seen to make for the increase of fitness, and therefore for the increase of happiness. Happiness and fitness go together in any sphere. Therefore the law of natural selection or the survival of the fittest must not be condemned outright as a brutal law. Terrible it undoubtedly is, according to the higher morality, which, by the greatest of paradoxes, it has itself evolved. But if we look at it for one moment, if we observe its results in the future, we see that it is unquestionably a beneficent law. It dominates the history of living things without exception.

The Good in Men Lives After Them. What we call individuality or personality among human beings is only a special case of the great fact which biologists call *variation*. It is the complement of heredity, the tendency for the offspring to vary in some character, and in some degree, from the parent seems to be a universal property of living matter. Such a variation is absolutely distinct from any change produced in the child by education or environment. Generally speaking, acquirements are not transmitted to the next generation, but variations are; and this it is which gives them such vast importance in relation to the future of society. We will not say that acquirements are of no importance except for the individual, for it is one of the cardinal

facts of human life that the most valuable of acquirements, though they are not transmitted by physical heredity, are yet transmitted by *social heredity.* The learning of a Newton does not appear in his child, yet in a true sense we are all his children, and his acquirements have not died out; as has well been said "the good men *write* lives after them." So profoundly true is this that some thinkers have inclined to explain the whole of human history, and the whole difference between human society and societies of lower animals, in terms of social inheritance.

Nature does not Create, but only Selects. But for our present purpose the measure of truth in such arguments does not matter. Even granting that the acquirements of the individual may thus be made permanent and may thus be transmitted—just as his inborn variations may be transmitted, though by very different means—the great fact of the use of individuality remains. We can entirely ignore the distinction between variations and acquirements, and can still recognise that, in any case, it is the accomplishments of individuals that have made progress possible. We must never forget that natural selection does not create but merely *selects.* The truly originating or creative act is the production of variations, and the original character which is called variation in a rose is illustrated in the *individuality* of man. No biologist has yet been able to explain how it is that variation occurs, but our present business as students of sociology is simply to recognise that it does occur.

Biology teaches us that if there be no variation there can be no progress. Natural selection would still act among, for instance, the tigers—some of which, by assiduous practice, would have acquired bigger muscles than others; but the tigers thus selected would not transmit their bigger muscles to their offspring—there would be no evolution in the direction of strength.

The Things that Account for To-morrow. Apply this to man. Suppose that there were no variations in his case, and that we were all born identical. Since the environment of every man is different from that of every other—no two men have read exactly the same books—we should still come to differ from another. As the writer has said elsewhere, "Those who had made the most advantageous acquirements, such as industry or great knowledge, would tend to survive and prosper, while those who had made disadvantageous acquirements, such as laziness or the loss of sight or limbs, would be pushed to the wall. That process, of course, occurs in society at the present day to a greater or less degree, but it has only immediate and contemporary consequences. For if we recall the assertion that acquirements cannot be transmitted, we shall see that the selection of those who have made advantageous acquirements cannot benefit the next generation, since those acquirements die with their makers. The only process of natural selection which can result in progress is one which consists in the selection of favourable variations, the reason being that such are transmissible, and that the children of persons so selected will tend to inherit their parents' good fortune." Man himself is the product of the working of this law during past ages. In those ages, at any rate, acquirements had no value except for the day and the individual who possessed them. "It is inborn characters, including variations—and all inborn characters began as variations—that alone count for to-morrow."

Society is Made Up of Variations. In general we may say that *man is the least variable and the most adaptable of animals,* but we may be sure, nevertheless, that no two human individuals are absolutely identical at birth. It follows that society is not a collection or structure made up of similar units, but of units which are necessarily and constantly dissimilar. This is an ultimate biological fact which no social contrivance—and least of all any attempt to deny or ignore it—will affect. Obviously, it must have immense significance, especially if we remember that these dissimilarities tend to be inherited. How, then, must we interpret it sociologically?

Are we to welcome it or regret it? What is its relation to progress?

The answer is that through all the ages variations have constituted the raw material of progress. Unfit variations have rapidly disappeared; valuable variations, making their possessors fit, have enabled them to survive and multiply and to inherit the earth. If the value of variation be true of the lower animals, it is truer still of man; and this for several reasons. In the first place, since man is the least variable of animals, variations are rarer and have the worth of rarity. Far more important is the second consideration, that variation assumes a new form in the case of man—a higher form having a proportionately higher worth.

Genius is not Born to Die. When the biologists teach us that man is the least variable of animals, we should remember that they are speaking only of physical variation. When we ascend from the physical to the psychical plane we find that the dictum of the biologists is no longer applicable. Man is now the most variable of animals, or rather of spiritual beings; and it is because his variations are on this exalted plane that they are of such worth. Take Shakespeare, for instance; his individuality, personality, or genius was a case of psychical variation of great magnitude. A physical variation of similar magnitude would have been the possession, let us say, of half a dozen arms or hands, the worth of which would have been nothing at all, but the worth of Shakespeare's psychical variations was immeasurable. As Charles Reade said of Erasmus, in closing his greatest novel, "The words of a genius so high as his are not born to die: their immediate work upon mankind fulfilled, they may seem to lie torpid, but at each fresh shower

of intelligence Time pours upon their students they prove their immortal race; they revive; they spring from the dust of great libraries; they bud, they flower, they fruit, they seed, from generation to generation, and from age to age."

The World's Gain Through Books. And there is yet a third reason why human variation, which is psychical variation, is of such great worth. It is because of the possibility of social as distinguished from physical inheritance. A useful variation in the case of one of the lower animals is worth nothing to the race unless that animal have children which will inherit and transmit it. Now Kant and Herbert Spencer were bachelors; the psychical variation which expressed itself in their genius was not transmitted by physical inheritance—which, in any case, is terribly uncertain in matters of genius. Yet, society would have lost immeasurably without those conditions of liberty which, imperfect though they were, at any rate permitted them to say their say—to which men will listen to the end of time. This point, that psychical variation in man is of value because it can be transmitted to subsequent generations by means of books, is one of the utmost importance.

And now surely we see that if individuality or variation has been the first condition of all progress in the past, of all the base degrees by which we did ascend, individuality, or psychical variation in the case of man, is in even greater measure the first and essential condition of all human progress. The law of progress is this: *that everything which is new and true and good shall be given a hearing.* This doctrine, which the writer has endeavoured to base upon the facts of biology, will immediately introduce us to the great conception of liberty.

How Truth Begins to Grow. The law of organic progress, as demonstrated to us by the study of organic evolution, constitutes the immovable natural basis for the intuitive conviction of democracy that there should be a potential field-marshal's *bâton* in every soldier's knapsack. Furthermore, as the writer has said elsewhere, "we should recognise that the greatest present and future happiness is served by the freest and fullest possible exploitation of every kind of ability—provided, of course, that it be not exploited in anti-social acts. In permitting the superior to benefit by their superiority, we benefit ourselves and our descendants. Worth of any kind is always worth something to others than its possessor. The history of all progress, from the amœba up to man, is the history of the establishment and accomplishment of novelty, variations, individuality—all difficulties notwithstanding. In all ages collective devices, academies, royal societies, have stood for the repression of individuality. In the moral, philosophic, and religious history of the world the same has been true. Every truth starts as a heresy, and the supreme individualities, the supreme prophets, the founders of religions, the noblest of the noble dead, those to whom we owe almost everything that we rightly prize, have ever been poisoned, or crucified, or stoned, or mocked, or spat upon, and invariably by collective forces. In a sense, at least, Carlyle was right when he declared that "universal history—the history of what man has accomplished in this world—is at bottom the history of the great men who have worked here." But the rule is that there arises some collective apparatus, declaring itself to possess the spirit of its founder, and the necessary foe of all such new individualities as that which gave it its own birth.

Committees are not Productive. As the intelligence of man attains greater heights, and as the principle of the worth of the individual is seen to be sanctioned by biology and human history alike, we may hope that genius, individuality, worthy variation, will no longer have to fight the mediocre majority, but will ever receive a patient hearing. It cannot for ever remain true that a "prophet is not without honour save in his own country." The history of progress, physical, moral, artistic, philosophic, is a history of the ultimate triumph of individuality. "Universal history," as Carlyle called it, might indeed be written as a controversial treatise in favour of the worth of the individual. No crowd or committee ever produced a great work of art, or generated a new energy, or conceived a new truth—but individuals ever and always. For the moment we may afford to ignore the questions of the conditions which produce the individual. It is a profoundly important question, but our immediate business is to recognise that, when somehow he is produced, he is of supreme worth to society. We in this country are already prepared, by long familiarity with two names, for the recognition of the two great complementary forces which act in any society. These are the forces of conservatism and liberalism. Certainly, most sociologists are unable to discover any recognition of first principles by the political parties which to-day take to themselves these great names; here, then, we speak not of actual party politics, but of the fundamental sociological truths which our two great political parties would represent in a wiser world.

The Great Parties in the State. The conditions of organic evolution, as distinguished from its factors, are two—*heredity* and *variation.* We have already insisted at length upon the fact that without variation there could be no progress in the organic kingdom, just as without its expression, individuality, there could be no progress in the kingdom of man. It is now our business to emphasise more clearly than has yet been done the value of the complementary fact of heredity. Heredity is the principle of conservatism or conservation. Its highest business and duty is to *hold fast to that which is good.* The reader will remember the earlier part of this famous phrase—"Prove all things." What is it in the case of individual organisms that proves all things? Plainly it is none other than the principle of natural selection. Again, if there were no variation,

there would be nothing to "prove," nothing to "select." The more one contemplates this great saying of St. Augustine's, and the more that, in the light of the idea of the social organism, we compare social forces with those that act amongst individual organisms, the more impressed must we become with the beauty of the analogy. It is worth expressing in a more graphic form:

Natural Selection = "Prove all things."

Variation = Individuality = Liberalism.

Heredity = "Hold fast the good" = Conservatism.

Holding Fast to the Good. When we contemplate the worth of variation, individuality, originality, *creation*, we are apt, perhaps, to appraise the contrary principle at less than its true worth. Long ago—if we may allude to mere party politics for a moment—the Conservatives were called the "stupid party"; and when we contemplate heredity and variation in the realm of life, we see the force of the taunt. There is something stupid about heredity; it has no imagination or initiative; it merely *holds fast*. But let us for a moment consider what would happen if there were no heredity, or if, in the organic kingdom, that force were much weaker than it is. As before, countless variations or novelties would appear in successive generations of animals and plants. The disadvantageous variations would be weeded out by natural selection, while individuals with advantageous variations would flourish. But of what avail would this be for the race if the children of such individuals did not tend to inherit their parents' advantages? Even as it is, such children tend to "revert to type," the same being true in human life, as Mr. Galton has expressed in his law of "regression towards mediocrity." The whole possibility of organic progress has depended on the incompleteness of this reversion to type, on the fact that immediate heredity is strong enough to allow advantageous variations to be perpetuated, in some degree at any rate, in the descendants of those who first displayed them. Thus life has been enabled to hold fast to that which is good; otherwise the good would die with the individual and there would be no progress.

What Would Happen Without Conservatism. And in human society the principle of conservatism is equally valuable, "stupid" though we may call it. Without it, what would happen? Obviously, we should be without any security for the permanence of the valuable. All sorts of novelties or variations would continue to spring up in all directions. We must never forget that though all progress depends upon the emergence of new characters or new ideas, yet not all new characters and new ideas are valuable; the great majority of them, unfortunately, are much worse than worthless. They are reversions or "throw-backs" to more primitive ages. A congenital idiot is a variation; the birth of such an idea as Nietzsche's, that morality is a delusion, is also a variation, and a pestilent one. It is the old brutality cropping up again. Hence, without the conservative tendencies displayed in varying degree by all of us, each successive generation would be in danger of letting go the good and suffering from the evil until natural selection destroyed it. Take, for instance, the institution of marriage. At the present time this is assailed by a host of prophets of a new social order, their new ideas being, in reality, mere "throw-backs" or reversions to the ideas of remote ages, happily long forgotten. If society had not its conservative forces (so exactly corresponding to the force of heredity in individual organisms), marriage would doubtless be abandoned—for a time. It will be maintained, however, by those conservative forces, which hold fast to that which is good.

The Better Will Prove Itself. The reader will retort, of course, that in any given case people will differ as to the goodness or badness; but, just as natural selection or the survival of the fittest, acting as umpire, upon the age-long duel between heredity and variation, has always proved itself able to prove all things, so the same is true in human society. Both sides must have a hearing, and the ultimate issue will be good. This great principle tempts the writer to discuss it in his own words; but this would not be fair to the reader, for it is fortunately possible to invoke the literature of the past on its behalf. In modern literature there is no expression of this principle to approach the second chapter of Carlyle's "Past and Present." There are five pages of this from which it is difficult to choose; but here, perhaps, is the paragraph which best expresses our principle, which, be it remembered, is nothing less than the mighty principle of toleration. Carlyle has been discussing Noble Conservatism and Ignoble Conservatism. Little could he guess—writing in 1843—that a quiet student called Darwin, of whom he had never heard, was at that moment filling his notebook with facts proving that Carlyle's words were based upon "the solid ground of nature." To our mind this is a fine example of the faith which anticipates knowledge.

The Eternal Struggle Between Right and Wrong. "For it is the right and noble alone (says Carlyle in "Past and Present") that will have victory in this struggle; the rest is wholly an obstruction, a postponement, and fearful imperilment of the victory. Towards an eternal centre of right and nobleness, and of that only, is all this confusion tending. We already know whither it is all tending; what will have victory, what will have none! The heaviest will reach the centre. The heaviest, sinking through complex, fluctuating media and vortices, has its deflexions, its obstructions—nay, at times its resiliences, its reboundings; whereupon some blockhead shall be heard jubilating, 'See, your heaviest ascends!' But at all moments it is moving centreward, fast as is convenient for it; sinking, sinking; and, by laws older than the world, old as the Maker's first plan of the world, it has to arrive there. . . . Fight on, thou brave, true heart, and falter not, through dark fortune and through bright. The cause thou

fightest for, as far as it be true, no farther, yet precisely so far, is very sure of victory. The falsehood alone of it will be conquered, will be abolished, as it ought to be; but the truth of it is part of Nature's own laws, co-operates with the world's eternal tendencies, and cannot be conquered. . . Seek through this universe, if with other than owl's eyes, thou wilt find nothing nourished there, nothing kept in life, but what has right to nourishment and life. The rest, look at it with other than owl's eyes, is not living; is all dying, all as good as dead! Justice was ordained from the foundations of the world, and will last with the world, and longer."

The First Preacher of Toleration. The extraordinary parallelism between this chapter and the principles of Spencer and Darwin is worth pointing out, if only as a contribution to the history of thought. We of this generation may learn from it, too, for Carlyle despised the evolutionists, and called Spencer "the most immeasurable ass in Christendom." Many of them, also, would have liked to suppress Carlyle, but, thanks to the principle of toleration and individuality, both expressions of the truth were permitted to be heard—and *we* benefit proportionately. It is a great lesson.

If now we turn to the fifth chapter of the Acts of the Apostles we find what Sir Leslie Stephen considered to be the first expression on record of the principle of toleration—this great principle, the worth of which, by her recognition both of heredity and variation, Nature teaches us, and yet which in the twentieth century we are only slowly beginning to learn. When the crowd, with its "ignoble conservatism," "took counsel to slay the Apostles," Gamaliel stood up in the council and said: "Refrain from these men, and let them alone, for if this counsel or this work be of men, it will come to nought; but if it be of God, ye cannot overthrow it, lest haply ye be found even to fight against God."

Truth is Able to Look after Itself. Here, then, is the great lesson for the partisan. We must hear all sides, strong in the faith that truth is great and will prevail. We may be absolutely convinced that we are right and that our opponents are immeasurably wrong; but let them have their say. Truth will prevail, and never more certainly than by the mutual slaughter of opposite extremes.

Let us just consider the two methods by which we may seek to establish what we believe. The one method is, in its extreme form, to assert our belief, to compel everyone to avow it, and to destroy every statement of any other opinion. This is the legal method, and it has been adopted in all ages. It was on this principle that the Church burnt Bruno and silenced Galileo; it was on this principle that the Athenians poisoned Socrates. This is the "ignoble conservatism," which not only disbelieves in variation or liberalism, but disbelieves that there are any laws of Nature which will ensure that evil cannot prevail. If you have no such faith, evidently it is your duty, whenever you can, to burn, poison, imprison, gag, vilify, or otherwise silence all who disagree with you. Truth is not safe, you believe, unless these methods be adopted. Nature is not on her side, and Truth's only chance is that no one be ever allowed to say anything that is false. Half the evils of human history—religious persecution, wars of religion, judicial murders of the great and good and divine, have been based upon this principle—that *the only chance for the survival of the truth consists in the employment of brute force.*

Nature is on the Side of Truth. The other method by which we may seek to establish the truth is by the principle of freedom of speech. The idea underlying it is the essentially noble and religious idea that Nature is on the side of truth. It is the idea of the survival-value of truth. In a society which believes in this principle there will be room both for Conservative and Liberal newspapers; and the Liberals, for instance, will not think that all would be well if only the Conservative Press could be suppressed. In such a society the men of science will not seek to silence the dreamers and the prophets, nor the dreamers and prophets to silence the men of science. What need to fear the false if the false has but to show its face to be ground into the dust? Nor dare we forget that if history teaches us anything, it is that brute force employed on behalf of what was believed to be true has only too often been prostituted to the service of the false—with vengeance sure.

Freedom of speech, then, freedom of thought, and "the liberty of prophesying"—these are the natural and warrantable means, in strict accordance with Nature's own methods, by which progress may be attained. It is very difficult indeed to live up to these principles. Let us suppose that you are a conscientious and humane physiologist; would you not be very much tempted, if you had the power, simply to suppress all anti-vivisectionists? And yet you would be wrong. The right way in which to combat false ideas is by true ideas, and not by brute force.

The Battle of Ideas. But the great principle of selection and survival has undergone a transmutation in our own times and a transfiguration from the physical to the psychical. We live not by our muscles so much nowadays as by ideas, and that society is healthy and prosperous where the battle of ideas is most strenuously and fairly and openly fought; where the only argument is argument and not brute force; where everything that can make itself articulate is heard, and where, therefore, if it be false, it is the soonest forgotten. Just as heredity and variation stood for the complementary forces of progress on the plane of the physical, so conservatism and liberalism, in society, in politics, in science and religion and art, are the complementary forces of progress on the plane of the spiritual.

The struggle now is not between thew and thew but between thought and thought. If we desire to ascertain the best conditions of that struggle we must turn again to the supreme adjudicator Nature.

Continued

THE AMAZING TELEGRAPH

Telegraphs that Print their Messages. The Baudot, Hughes, and Murray Systems. How a Man Sitting in London can Print in Rome

Continued from page 5244

By D. H. KENNEDY

The Wheatstone Automatic System. It was stated on page 4385 that three instruments —namely, the perforator, the transmitter, and the receiver are necessary for this system. For convenience, however, double-current sounder system apparatus is added to each end of the line, to enable the telegraphists to communicate corrections and acknowledgments. A rheostat and condenser are also necessary if speeds above 300 words per minute are required.

The Perforator. The mechanism of this instrument [**8**] is arranged so that the keys operate five punches, which are arranged as follows:

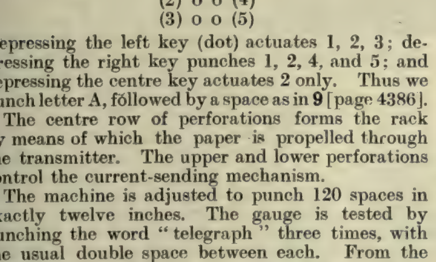
(1) o
(2) o o (4)
(3) o o (5)

Depressing the left key (dot) actuates 1, 2, 3; depressing the right key punches 1, 2, 4, and 5; and depressing the centre key actuates 2 only. Thus we punch letter A, followed by a space as in **9** [page 4386].

The centre row of perforations forms the rack by means of which the paper is propelled through the transmitter. The upper and lower perforations control the current-sending mechanism.

The machine is adjusted to punch 120 spaces in exactly twelve inches. The gauge is tested by punching the word "telegraph" three times, with the usual double space between each. From the beginning of the first "t" to the end of the last "h" there are 121 spaces, and the distance, centre to centre, between the first and 121st should be precisely one foot.

Pneumatic Perforators. At certain offices, such as the London News Division, it is necessary to prepare simultaneously several slips. For this purpose the assistance of pneumatic power is invoked. Figure **65** shows such an arrangement. The operation of the three white keys controls the air supply to two sets of plungers, which

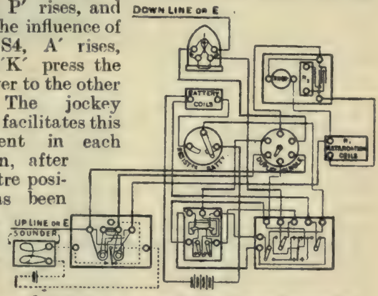


63. TRANSMITTER MECHANISM

take the place of the operator's mallets. As plenty of power is available, double or treble rolled slips may be used, and it is possible to arrange for as many as eight slips at one operation. A higher speed is made possible, as the keys are so light as to render the use of mallets unnecessary.

The Transmitter. The transmitter is shown on the right in **66**. Under the control of the perforated paper it performs the work of a double-current key, producing signals of unvarying excellence, and at a speed ten to twenty times that of its human rival. The controlling mechanism is shown in **63**. DU is the compound reversing lever, the front portion, U, being insulated from the rear portion, D. They are connected to the lines as shown, and it will be seen that the contacts are placed so that when the top of the lever is deflected to the left a positive current goes to the "up" line, and a negative to the "down."

When the transmitter is running free of slip, its clockwork rotates the wheel W, and also causes the lever, PP′, to rock on its centre. Now when P presses down A, H and K are moved to the left. Simultaneously P′ rises, and under the influence of spring S4, A′ rises, and H′K′ press the lever over to the other side. The jockey wheel J facilitates this movement in each direction, after the centre position has been passed. In later forms a *magnetic bias* has been introduced instead of the jockey wheel. It will be seen that when running free of paper a series of alternating currents are sent to line, which produce dots, or, as they are called, *reversals*, on the distant receiver.



64. CONNECTIONS OF WHEATSTONE DUPLEX SET

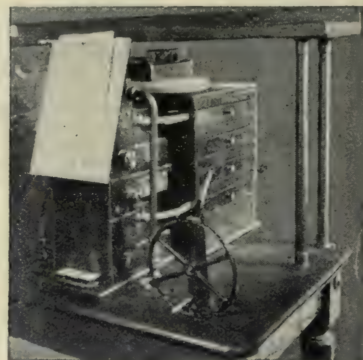
Now we must consider what takes place when the slip is inserted. An important point to note is that the rod S is not parallel with, but, as shown, in *front* of, the rod M. Imagine that we insert the slip [**9**, page 4386]. It reaches M first, and prevents it from rising; S rises and at the next oscillation of PP′ it also is held down, and the points of both slide along, waiting for a hole in the paper. Meantime, in consequence of the fact that S rose *last*, a spacing current is being sent to line. At length M passes up through the first upper hole of the letter C, and is immediately withdrawn again; this, however, causes a marking current to be sent, which continues until S passes up through the first bottom hole in the paper, and causes a spacing effect. Immediately afterwards M passes through the upper hole of the dot, and is withdrawn. This begins a marking signal for the dot, which is immediately terminated by the rod S passing through the bottom hole, and so on, signal by signal. At the end of the word the rod S is the last to come into action, and so the spacing current persists until the paper runs out, when the reversals begin again. Six hundred words per minute is the maximum speed, and it is interesting to note that at this speed a dot signal persists for $\frac{1}{300}$th part of a

second. Such high speed is, however, seldom called for, and 200 words per minute is general.

As indicated in the connection diagram [64], the starting lever of the transmitter, visible on the left, also actuates a switch which diverts the battery and line connections from the key to the transmitter.

The clockwork is impelled by a heavy weight, which is wound up by a handle which projects from the front. The running speed is regulated by the lever at the top, behind the case. It can be clamped in any desired position. The curved pins in front of the transmitter are used to retain the ends of used slips for a short time in case a retransmission is required.

The Receiver. The receiver, visible on the left in 66, is a combination of the principles already described in the P. O. S. Relay, and the Inkwriter. By means of clockwork a thin blue paper slip is drawn over a roller, and the same mechanism rotates an inking wheel in a direction opposite to that of the paper. An electromagnet, built on the same lines as a P. O. S. Relay, and connected directly in the line circuit, controls the wheel. The marking disc does not, as in the inkwriter, rotate in the inkwell. It takes its supply from the upper edge of a larger wheel, the lower part of which rotates in the ink. What corresponds to the tongue of the relay directly controls the axle of the marking disc, and so reproduces signals. In addition, however, a local contact is provided at the bottom of the electromagnet, to which the sounder is connected.



65. PNEUMATIC PERFORATOR

The clockwork of the receiver in 66 is impelled by a spring. The speed regulator is in the same position as on the transmitter. The adjustment of the electromagnet armature is made by means of the milled nut which projects above the case.

Two slip drawers can be seen in the base. Each of these contains a rotary slip carrier. Two boxes are provided to prevent the possibility of a despatch being lost owing to the slip running out. To this end also each roll of slip has near its inner end a few convolutions of red slip. As soon as this appears, opportunity is taken to slip in the beginning of a roll from the second box.

Wheatstone Duplex. The Wheatstone system can be duplexed, and 67 shows a set arranged for working in both directions. The speed attainable in each direction is about two-thirds of that possible under simplex conditions. The receiver shown in this set is provided with a weight motor train. The bell fixed on the right side gives indication when the weight requires rewinding.

66. AUTOMATIC WHEATSTONE SET
For high-speed working with spring-type receiver

A connection diagram is given in 64. To facilitate balancing for duplex working, a two-way switch is provided so that the battery power may be cut off the line and an equivalent resistance substituted.

Keyboard Perforators. Attempts are now being made by inventors to reduce still further the labour and to lessen the time consumed in preparing the perforated slips. Figure 68 depicts the Kotýra system, which is at present (1907) undergoing experimental trial at St. Martin's le Grand.

On the right there is a three-tier pneumatic perforator which can prepare simultaneously twelve slips. Its plungers are controlled from the *Kotyra* keyboard. The little electric motor on the left rotates a cylinder. This is provided on its surface with teeth, which the under-surface of any key engages on depression. The key is drawn backwards away from the operator and makes a suitable series of contacts, closing the circuits of three electromagnets, which, in turn, control the pneumatic perforators. Having performed its duty, the key is released by a trigger action, and returned to its place by means of a special spring. The operator must wait for this release before depressing another key.

It has been proposed to apply the Kotyra keyboard direct to the line, so that, instead of forming the Morse signals by hand, the operator would press the Kotyra keys, and the feasibility of this method has actually been demonstrated, the services of an operator who, owing to an attack of telegraphists' cramp, was unable to send in the ordinary way being thus utilised. It will be noticed that the system resembles closely that which was invented by Professor Morse, and which preceded the invention of the Sounder System.

Yetman Transmitting Typewriter. Another competitor in the same field is the Yetman. Two forms are shown in 69; that on the right is used for sending in the way suggested for the Kotyra. The instrument on the left combines, in addition to the electrical sending portion, the functions of a typewriter, so that it produces a record of the letters sent.

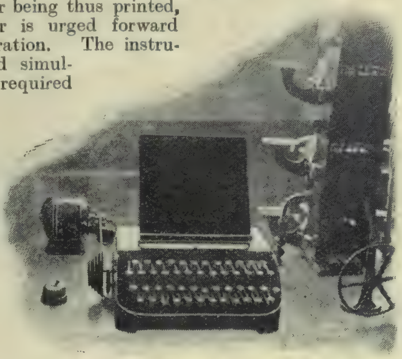
Creed Perforator. A more ambitious arrangement is that shown in 70 and known as the Creed Keyboard Perforator. The mechanism of an ordinary typewriter has been modified so that on depressing a key it makes the appropriate selection from a set of twenty punches, and produces the perforated letter at one stroke. A speed of sixty words per minute can be maintained. As in the cases already mentioned, pneumatic power at a pressure of 10 lb. per square inch is used, and four slips can be produced simultaneously.

Type Printing Telegraphs. It is probable that no department of telegraphy has been the subject of more patent specifications than this one,

although the successful systems are few indeed. Five interesting systems have been chosen for illustration.

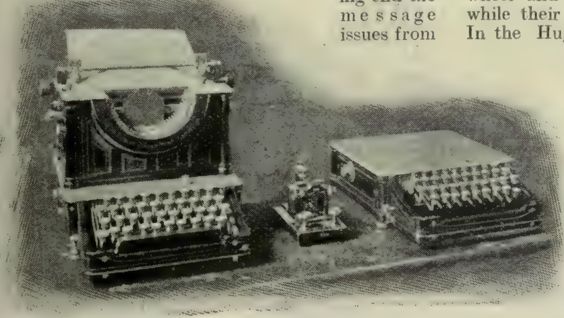
67. DUPLEX AUTOMATIC WHEATSTONE SET

The Steljes Type Printing Telegraph. This is a system based on the Wheatstone A B C, the A B C indicator being displaced by a Steljes recorder, which prints the signals sent by a Wheatstone communicator in Roman letters on a paper tape [**71**]. The received alternating currents pass through two electromagnets joined in series—one is polarised, the other non-polarised. The armature of the polarised relay oscillates, and in doing so allows an escapement wheel to turn forward—one tooth for each letter current. On the same axle is the letter wheel, which can be seen just above the paper, and has above it an inking-wheel brush. The same series of currents in passing through the non-polarised relay attract and hold its armature until the currents cease. The armature then drops and allows a printing-lever to jerk the paper up against the letter wheel, the required letter being thus printed, and simultaneously the paper is urged forward in readiness for the next operation. The instruments at both ends record simultaneously, and no attendant is required at the receiving end. By an ingenious arrangement three revolutions of the communicator needle secure that the recorder shall start from zero. Had the invention of this instrument preceded the telephone it would have had an enormous sale. It still finds a large field for its use—superimposed on telephone lines—in confirming messages transmitted orally.



68. KOTYRA KEYBOARD PERFORATOR

The Hughes Printing Instrument. This has so far been the most successful system. Some thousands of instruments are in use on the Continent and on the cables between this country and the Continent. Figure **72** shows a set in use between London and Rome. The sending is done by means of a keyboard resembling that of a piano. At the receiving end the message issues from the instrument printed in Roman characters on a tape, which the operator breaks off into suitable lengths and pastes on a form, in which state it goes out for delivery. When a message is sent, both receivers are actuated so that mistakes are at once visible to the sender.



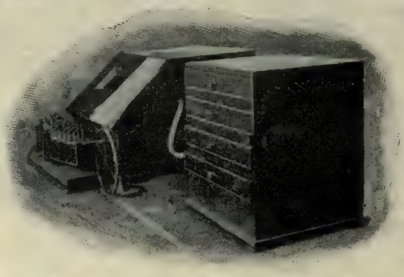
69. YETMAN TRANSMITTING TYPEWRITER

By means of a most admirable mechanism it is arranged that the sending contact-makers and the receiving printing wheels at both stations shall revolve continuously and synchronously, so that at any given instant all four are opposite the same letter. If, then, a key is depressed at either end a contact is made, and simultaneously the letter is printed at both stations. The synchronism is regulated by a vibrating spring. Only one current is sent for each signal. It has the effect of releasing an armature from an electromagnet, and this immediately sets in motion a train of mechanism which prints the letter, moves the paper forward, and replaces the armature in readiness for another signal. Synchronism is maintained by means of a correcting cam, which is forced between the teeth of a star-wheel fitted on the printing axle, and adjusts it each time a letter is printed.

It is instructive to contrast the Steljes system with the Hughes system. In the former a succession of currents urges forward the printing wheel and maintains the necessary synchronism, while their cessation produces the printing effect. In the Hughes the synchronism is arranged for mechanically. A *no-current* time interval takes the place of the succession of currents just referred to, and its termination is marked by the single current.

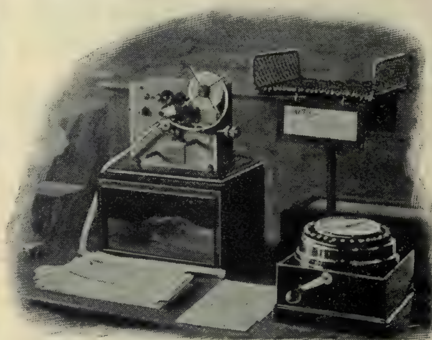
The Hughes type-wheel is *not* stopped, or even retarded during the printing process. In both systems it will be noted that only a limited number of letters per revolution can be manipulated—the average number is two—and that this determines the speed. In the case of the Hughes, however, the rate of rotation is high, and the average speed of working is about forty words per minute.

The Hughes instrument can be worked on a duplex system. The differential method is employed in the same way as has already been described in the case of the single-current sounder. Figure **75** illustrates a duplex set which is worked between London and Berlin. Of course, one of the instruments is used continuously for sending and the other for receiving. Between the two Hughes sets can be seen the single-current key and switches which enable Morse signals to be used during the balancing process.



70. CREED KEYBOARD PERFORATOR

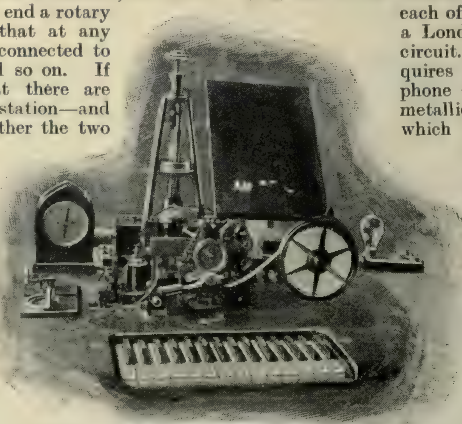
The Baudot System. In the Baudot system [**73**] signals are received in Roman characters on a printed tape exactly as in the Hughes system, but the means by which this is achieved are entirely different. M. Emile Baudot originated a system in which the alphabet is arranged so that every letter requires the same number of signal units, and the aggregate number of signals is the smallest possible. The signals are permutations of five *space* and *current* units, and to produce them the operator is provided with a sending instrument having five keys similar in appearance to those of the pneumatic perforator. Corresponding with the five sending keys there are in the receiving instrument five electromagnets, which repeat the signals given by the keys, and by means of a very beautiful mechanism actuate the printing wheel so as to produce the required Roman characters.



71. STELJES TYPE PRINTING SET

It would seem that this arrangement would necessitate five wires between the two stations, but this is obviated by having at each end a rotary distributor arranged so that at any given instant No. 1 key is connected to No. 1 electromagnet, and so on. If the reader imagines that there are two clocks—one at each station—and that the line connects together the two minute hands, then, if the clocks keep accurate time, and we suppose that No. 1 key is connected to 12 o'clock at one end and No. 1 electromagnet to 12 o'clock at the other end, it is clear that if we arrange for electrical contact between the figure and the pointer the instruments will be in connection once every hour. This principle of rotary synchronism is used in the Baudot system, but instead of one revolution per hour we have 180 revolutions per minute, and instead of arranging for one instrument with five keys, it is found possible to arrange for four instruments each having five keys, so that four operators are required at each end, and they can work independently as if they had separate circuits. There is, however, one limitation. The rotary distributor connects a given instrument through to the corresponding receiving set three times per second, and the signals between those sets must be sent during the connected interval or they will be lost. The operators are, therefore, trained to send exactly three signals per second, and to enable them to make their signals at the correct instant "watch receiver" telephones are provided which give a click each time that the distributor connects up the instrument to the line. It is found that in course of time operators become so accustomed to this "cadence," as it is called, that they can work with perfect accuracy even without the aid of the telephone signal.

The illustration [**73**] gives a view of one of the three sets which work between London and Paris. On the left can be seen the rotary distributor, and, beginning from the centre, the four telephones on projecting brackets are visible, and beside them the sending keys and receiving instruments. The heavy weights visible beneath the table are provided with electric motors which come into circuit automatically and wind up when required.



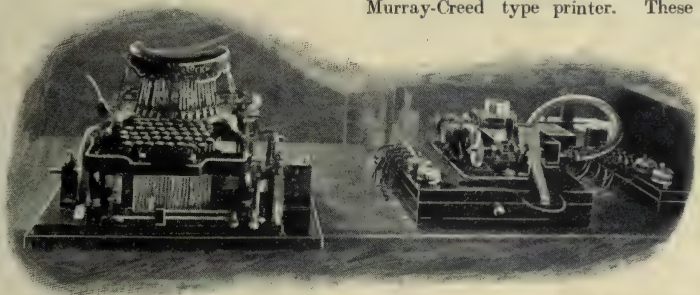
72. HUGHES PRINTER, SIMPLEX SET

Baudot Superimposed on Telephone Trunk. A still more interesting fact in connection with two of the London-Paris Baudot sets is that each of them is superimposed on a London-Paris telephone trunk circuit. A telephone circuit requires two wires, and the telephone currents pass around the metallic loop. By a method which will be described in the telephone section, the two wires in parallel are utilised to carry the Baudot signals in such a way that there is no interference. When we consider that two small wires can in this way be used simultaneously for one telephonic conversation and four telegraph messages, we realise that if electricians have still to acknowledge their ignorance of the nature of electricity, they have at least made substantial progress in the knowledge of how to control and use this mysterious and wonderful force.

73. BAUDOT FOUR-WAY SET

The Murray Type-printing Telegraph. One of the latest developments in type printing by telegraph is the Murray system, which for the last three years has been on experimental trial by the Post Office Department, in regular service, between London and Edinburgh and London and Dublin. The Murray may be said to bear the same relation to the Baudot as the Wheatstone set does to a Sounder system. The Baudot alphabet is used, but, as in the case of the Wheatstone three separate operations are necessary, though these are largely made automatic. The messages are first produced on a punched slip by means of a keyboard perforator. The slip is then passed through a transmitter, somewhat similar in principal to the Wheatstone. The receiving instrument, however, also produces a perforated tape similar to that which has been used at the sending end. The perforated tape is then passed through the instrument known as the "Murray Printer," and this instrument reverses the process of the keyboard typewriter, and types the message. It stops automatically at the end of each line, and the only office required from the operator is that of returning the paper carriage in readiness for the beginning of the next line. It is wonderful to watch one of these instruments typing as if with the aid of an invisible operator at the marvellous rate of 120 words per minute.

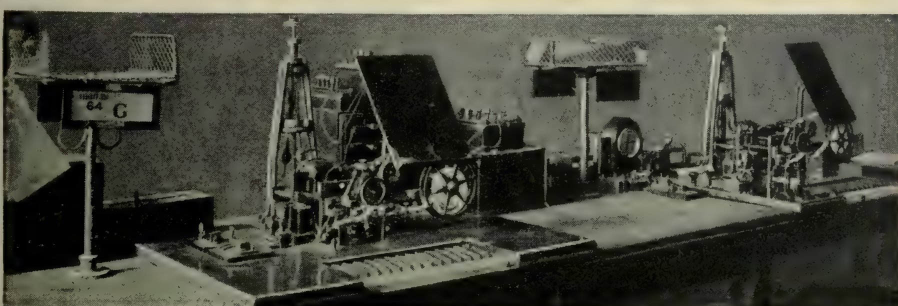
Mr. Murray has also conceived the idea of applying his instrument to operate a Linotype keyboard, so that it is quite conceivable that on some future date one of our great London dailies may have its type set up by an operator sitting, say, in Paris.



74. MURRAY-CREED TYPE PRINTER AND CREED RECEIVING PERFORATOR

The Murray Creed System. The two instruments shown in **74** are: on the right the Creed receiving perforator, and on the left the Murray-Creed type printer. These instruments produce results similar to those described in the case of the Murray, but the alphabet used is the same as in the ordinary Wheatstone system. It is therefore possible to substitute the Murray-Creed receiving perforator for the Wheatstone receiver on any ordinary Wheatstone circuit. The tape which issues from the instrument is the ordinary Wheatstone perforated tape, and it can be used either in the Murray-Creed receiving type printer, or in the ordinary Wheatstone transmitter for retransmission on other lines.

Continued



75. HUGHES PRINTER, DUPLEX SET

THE EVOLUTION OF SWEDEN

The First Years of Sweden's Independence. Gustavus Adolphus and Wallenstein. The Decline of Spain's Greatness. Discovery of Brazil

By JUSTIN McCARTHY

THE NORTHERN KINGDOMS

The Union of Calmar, in 1397, brought Denmark, Sweden, and Norway into one state under Eric XIII., each kingdom retaining its own laws and customs, and its own legislative assembly. Sweden soon withdrew from the Union and became an independent state, and, despite the actual terms of the Union, Denmark endeavoured to exercise something like despotic authority over her partners.

Sweden's Deliverer. Christian II., sovereign of the three kingdoms, was a tyrant who would not endure opposition to his will; when he found much resistance in Sweden he ordered a massacre of some of the leading men in Stockholm, and thus roused the country against him. Gustavus Vasa, who belonged to the high nobility of Sweden, was one of those who led the movement against Denmark some time before. He was then treacherously seized and carried off to Denmark as a hostage. He escaped in disguise after a year, and returned to his country, where he tried, but without much success, to arouse the Swedes into an organised rising against the Danish power. He had to retire to Dalcaria, and led for some time a life of romantic wandering, working unrecognised, sometimes as a farm labourer and sometimes as a miner, with a great price on his head. At last, in 1520, the "Blood Bath" of Stockholm aroused the Swedes to passionate resistance, and then Gustavus Vasa came to the front, was welcomed by the people, and soon created and commanded an army large enough to make an effectual fight. It ended three years later in the capture of Stockholm, and the expulsion of the Danes from Sweden. Gustavus was raised to the throne as Gustavus I. in 1524, and in the following year the Union of Calmar was torn to pieces.

Development of the Country. Gustavus reigned for forty years, and his rule made Sweden once again a free and prosperous country, with a large army, a prosperous exchequer, and a thriving population. He established schools and colleges, and promoted education; opened up roads, bridges and canals throughout the country; made commercial treaties with other countries and did much to promote trade. He was devoted to the Lutheran faith, and did his best, like many other European princes, to suppress the Catholics. He died on September 29th, 1560, and was succeeded by his eldest son Eric XIV., whose rule was in every sense unfortunate, for he was practically a madman, and involved his country in costly and useless wars. After eight years he was deposed by his brother, John III., who was inclined to favour the Jesuits, like his son, Sigismund, who succeeded him in 1592. The Protestant party therefore deposed Sigismund in 1600, and made his uncle, Charles IX., king. Gustavus Adolphus, grandson of Gustavus Vasa, succeeded in 1611, as Gustavus II., who brought Sweden back to strength and prosperity such as she had not enjoyed since the days of his grandfather.

He came to the throne when he was seventeen owing to the disputed succession of his father. He secured the support of the nobles by confirming their privileges, reorganised the government, and created a large army; made war with Denmark and recovered the Baltic Provinces. He also made war on Russia, and this war was ended by the Treaty of Stolbova in 1617. By this treaty Sweden obtained Ingermanland, Karalia and part of Lavonia, while Russia recovered Novgorod. In 1618, Gustavus visited Germany, and two years later married the daughter of the Elector of Brandenburg. His dispute with Poland was ended in 1629 by a six years' truce.

Gustavus and Wallenstein. Gustavus was, like his grandfather, a Lutheran, and he raised an army to support the Protestants of Germany. These struggles brought into great prominence the celebrated Wallenstein, a great soldier of indomitable ambition. He made himself an object of dread to the Princes of the German Empire, who prevailed on the Emperor to dismiss him from the command of the army. The successes of Gustavus Adolphus, however, compelled the Emperor to restore Wallenstein on his own terms. Wallenstein raised a large army and obtained a success over Gustavus at the battle of Lutzen, in 1632; the result was for a long time uncertain, but in the end the army of Wallenstein was completely defeated by the Swedes. The battle was fatal to Gustavus. During the battle he received three wounds and fell from his horse to the ground. A soldier of the enemy asked "Who is there?" "I was the King of Sweden," replied Adolphus, and the man shot him through the head.

His daughter, Christina, succeeded him, but in 1645 she resigned the crown to her cousin, Charles X. This King defeated Sigismund of Poland in a terrible battle at Warsaw in 1656, which lasted for three days, and he also succeeded in expelling the Danes from the continent of Sweden. He died in 1660, and his son, Charles XI.—then only a child—came to the throne.

Charles XI. was followed by the greatest King of Sweden since Gustavus Adolphus, Charles XII., often called "The Madman of the North," whose strange career has given a subject to many poets.

A Romantic Career. Charles XII. was born on June 27th, 1682. His succession was regarded by Russia, Poland, and Denmark as a favourable opportunity for an attack upon Sweden, but the young king, having some help from England, promptly compelled the Danes to make terms of peace, and afterwards defeated the Russian army at the famous battle of Nava, on November 30th, 1700. He dethroned King Augustus II. of Poland and compelled him to sign humiliating terms of peace in 1706. In the following year he led an army into Russia, and for a time drove the Russians before him; but he suddenly changed his plans, relying too much on the promises and counsels of the Cossack leader, Mazeppa, who has been made famous in poetry and the drama. Charles's military strength became much wasted, and when, after a winter of terrible privations for his troops, he laid siege to Pultowa, in Russia, he was completely defeated. He afterwards engaged in many other wars, won victories, suffered defeats, had thrilling escapes from capture and other dangers, and finally came to terms with the Tsar by ceding to him Sweden's Baltic Provinces. With the aid of the Tsar he proposed to conquer Norway, and then to make an expedition into Scotland and, with the help of the Jacobite party there, and of Cardinal Alberoni on the Continent, to replace the Stuart family on the throne. But all these venturesome plans were brought to an end, for Charles was killed while laying siege to Fredrikshall on December 11th, 1718.

SPAIN

From the time of the defeat of the Spanish Armada in 1588 the greatness of Spain gradually declined. Philip II. had been an absolute ruler, and had introduced the custom of raising money without the consent of the Cortes, which, indeed, was seldom summoned. The power of Spain by land and sea, her wealth, her industries, and even her population, decreased, and after the death of Philip II., in 1598, the history of Spain is chiefly told in the history of other countries. His son, Philip III., was much under the influence of favourites; he was succeeded in 1621 by Philip IV., who, though a man of some talents, had no capacity as a ruler. The story of the Thirty Years War and of the War of the Spanish Succession has already been told. Portugal and her colonies, which had become part of the Spanish dominions in 1580, were lost to Spain in 1640, after a brief struggle. Charles II. (1665—1700) had no children; with his death ended the Austrian dynasty, and Spain was now regarded by the great Powers of Europe as their prey.

Charles II. nominated as his successor the grandson of Louis XIV., and then came the War of the Spanish Succession. Philip V., who was proclaimed King at Madrid in 1700, was the first of the Bourbon Sovereigns. He introduced the Salic Law, which was the cause of much trouble later on. In 1724 he resigned his crown to his son, but on his death a few months later Philip again ruled—at least nominally, the country being really governed by his second wife, Queen Isabel, and Alberoni, her Minister. After Philip V. came Ferdinand VI., and then Charles III., the best of all the Bourbon Kings. He made many reforms in the government of the country, and under his rule Spain was more prosperous than she had been for many years. In 1788, Charles III. died, and was succeeded by his son, Charles IV., during whose reign occurred the French Revolution, which for a time changed the face of European politics.

PORTUGAL

We have already traced the history of Portugal from its earliest days to the discovery of the Brazils by Cabral in 1500. Cabral was born about 1460, and on March 9th, 1500, he was in command of a fleet bound for the East Indies.

Discovery of Brazil. To avoid being delayed by a calm off the African coast, he took a course too much to the west for the purposes of his voyage, came in for the full influence of the Atlantic's South American current, and was carried, whether he would or not, to the then unknown coast of Brazil. Thus, like Columbus, he discovered an entirely new region by accident. He was equal to the occasion, however, and, landing on the shore of Brazil, claimed the whole country as part of the dominions of the King of Portugal, and effected an easy conquest. He established the first commercial treaty between Portugal and India.

In 1524 was born Portugal's greatest poet, Camoens, author of "The Lusiads." Camoens had been intended for the Church, but he declined to take Orders, and occupied himself with the composition of poems. He got into trouble with the authorities at Lisbon, and was banished from the city for a year. After an absence of sixteen years, he returned to Portugal, and in 1572 published "The Lusiads," which won a brilliant success.

In 1580, Portugal was seized by Philip II. of Spain, while the Dutch shortly after captured the Portuguese settlements in India. The Portuguese were, however, well capable of resisting invasion, and in 1640 put an end to the Spanish occupation, and made John, Duke of Braganza, the Sovereign of the kingdom. The war lasted for a considerable time, and was brought to an end by the Treaty of Lisbon in 1668.

The Methuen Treaty. An important event in the history of Portugal was the concluding of the Methuen Treaty between Great Britain and Portugal, on December 27th, 1703, by Paul Methuen, the British Ambassador at Lisbon. It favoured the importation of port wine into the British territories by lowering the duty, thus discouraging the importation of French wines. The Treaty was abolished in 1834.

The more recent history of Portugal is brought into close association with that of England and of France, because of the struggles between France and Portugal in which England frequently gave her armed assistance to the Portuguese. Portugal has ever since remained an independent kingdom, and has been, in spite of troublous questions of succession, a prosperous country.

Continued

Group 29
TRANSIT
24

SHIPBUILDING continued from page 5262

TYPES OF MODERN SHIPS

Varieties of Sailing Ships and the Methods of Rigging them. Construction of Hulls. Steamers and Steamer Construction

By Dr. J. BRUHN

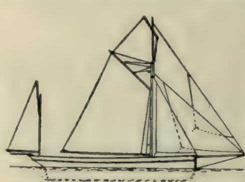
THE ships of to-day are classified into steam and sailing vessels according to their method of propulsion. There is a third type called the *auxiliary* ship, which is really a sailing vessel with a small steam-engine that can be used in case of calm. It is, however, very rarely met with now, it having been found that the purely steam or purely sail-propelled ship was in most circumstances the one that answered best. It was seen in the preceding article that the steamers now predominate to such an extent that it is only a question of a few years before sailing vessels will have practically ceased to exist. Even now the value of the world's sailing tonnage is only about one-tenth that of the steam tonnage. The steamers are further divided into single-screw, twin-screw, and paddle vessels, according to their method of propulsion. The turbine steamer is the latest addition to this category, but this description indicates only the type of the engines adopted. All these classes are again divided into three, according to the building material being wood, iron, or steel. There is also a mixed construction called *composite* where the framing is of steel or iron with wood planking, but it is very rarely adopted except in the case of yachts. The practical disappearance of wood and iron as shipbuilding material was also described in the preceding article. For practical purposes only steel ships are now built.

11. CUTTER

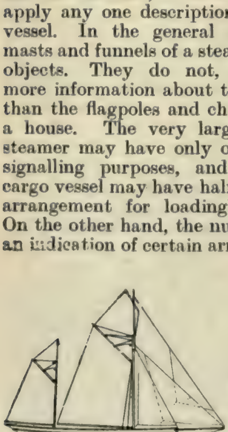
Steamers are further described according to their purpose as cargo, passenger, mail, coal-carrying, ore-carrying, oil-in-bulk steamers, etc., but these categories are more or less vague, and usually merge into one another, so that it may not be possible to apply any one description alone to any individual vessel. In the general outward appearance the masts and funnels of a steamer form most prominent objects. They do not, however, convey much more information about the character of the vessel than the flagpoles and chimneys do with regard to a house. The very largest and most important steamer may have only one or two pole masts for signalling purposes, and a comparatively small cargo vessel may have half a dozen masts to suit the arrangement for loading and discharging cargo. On the other hand, the number of funnels is merely an indication of certain arrangements of boilers, and is no definite criterion to the power developed by the engines.

Sailing Ships. In the case of sailing ships the outward prominently apparent features—namely, their rig or general arrangement of masts and sails—afford practically the only means of classification. In other respects all sailing vessels are alike, being constructed merely to carry a load of any kind of cargo from one port to another.

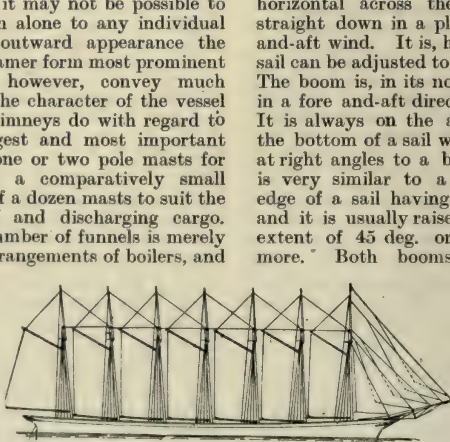
A knowledge of the various types of sailing ships is still essential to a naval architect, and a short description of them is therefore given here. To appreciate the differences between the various rigs it is necessary to know the broad principles of the disposition of sails. The masts of a ship are the nearly vertical spars that carry the sails. They are extended down through the decks to a firm foundation at the bottom of the vessel, and they are supported by strong wire ropes from their top to the sides of the deck or to the adjoining masts. At the fore end of all sailing ships a nearly horizontal spar is fitted, called the *bowsprit*. It serves the purpose of giving greater spread to the sails, which could otherwise be extended only over the length of the ship proper. Like the masts, it is supported by stays of wire rope, in this case to the stem of the ship and to the foremast. On the masts are hung spars to which the sails are made fast directly. There are three kinds of such spars—namely, yards, booms, and gaffs. The yard is, in its normal position, horizontal across the mast, and its sail hangs straight down in a plane at right angles to a fore-and-aft wind. It is, however, movable, so that the sail can be adjusted to suit the direction of the wind. The boom is, in its normal position, horizontal, and in a fore and-aft direction with regard to the ship. It is always on the after side of a mast and at the bottom of a sail which is, in its middle position, at right angles to a beam or side wind. The gaff is very similar to a boom, but is at the upper edge of a sail having a boom at the bottom one, and it is usually raised from the horizontal to an extent of 45 deg. or more. Both booms



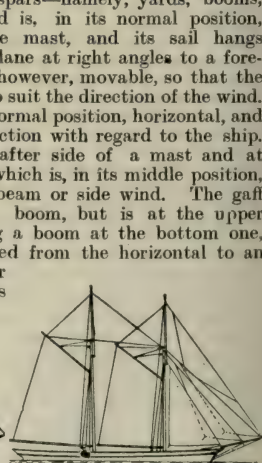
12. YAWL



13. KETCH

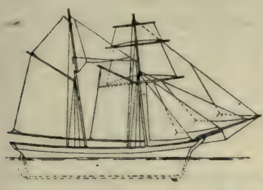


15. FORE-AND-AFT SCHOONER WITH SEVEN MASTS

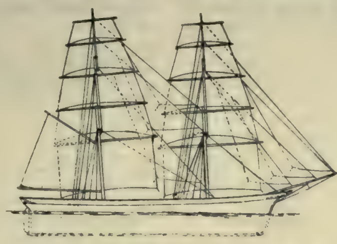


14. FORE-AND-AFT SCHOONER WITH TWO MASTS

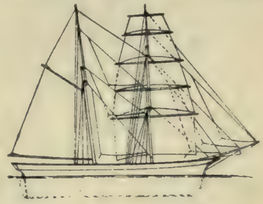
and gaffs are movable, so that the sail they expand can be adjusted to the direction of the wind. Such sails are called *trysails*, to distinguish them from the



16. ORDINARY SCHOONER



18. BRIG

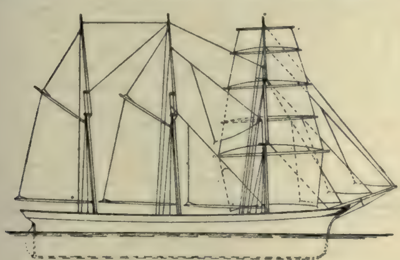


17. BRIGANTINE

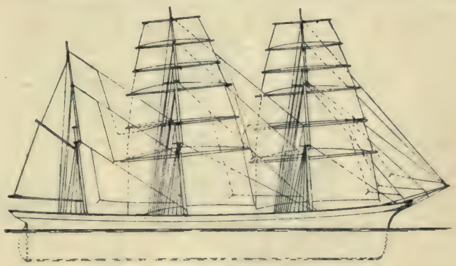
square sails or yard sails. In addition to these classes of sails there is a third kind—namely, *staysails*, which are not extended directly by means of spars, but are fastened to the steel fore-and-aft stays supporting the masts and the bowsprit. They are always triangular in shape, and have their normal position in a fore-and-aft direction, like the trysails.

Name of Masts. Where two masts are fitted, the first one from the fore end is called the *foremast* (except where the second one is a subordinate one, in which case the first one is called the *mainmast*); the second full size mast is the main mast. Where there is a third mast it is called the *mizzen-mast*, and if there is a fourth one it is designated the *jigger-mast*, if without yards, or *after-mizzen-mast* if with yards. The spars on the individual masts are called by the name of the mast. Thus, there is the fore yard, the main gaff, and the mizzen boom. There are only one boom and one gaff on a mast, but there may be several yards. The bottom one is always the lower yard. The next one is the topsail yard, or if this sail is fitted in two parts, the lower-topsail yard. Above the topsail yard comes the topgallant yard, or if the topgallant sail is in two parts, the lower topgallant yard. Above the topgallant yard is the royal yard, and if there is a yard above the royal one it is called the skyscraper yard. The arrangement of the sails depends to a certain extent on the size of the ship. From the point of view of simplicity it would be desirable to have as few masts as possible; but for the larger ships this would involve the use of individually unhandy sails, hence the introduction of one or more additional masts.

Types of Rigs. The *cutter rig* [11] is the one adopted in the smallest trading vessels, say from 50 to 80 ft. in length, and in yachts of moderate size. It has only one mast, the mainsail being extended by means of a gaff and a boom. The *yawl rig* is similar to

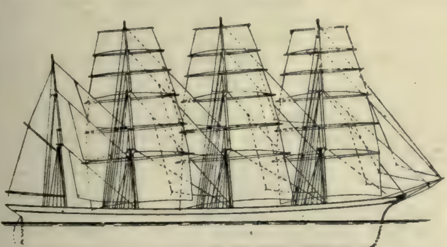


19. BARQUENTINE

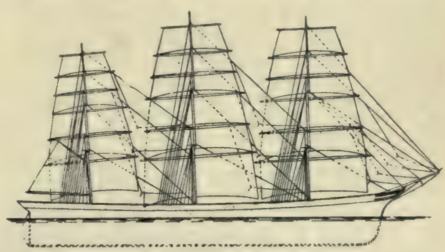


20. THREE-MASTED BARQUE

that of a cutter with a very small mast fitted abaft the mainmast as shown by **12**. It is applied to vessels about 60 to 90 ft. in length. The *ketch rig* [13] is practically a yawl with the after mast of slightly larger dimensions. It is adapted for vessels ranging from 70 to 100 ft. in length. The *schooner rig* is the one found in the greatest number of varieties. It is the rig adopted for the smallest seagoing sailing merchant vessels, and it is the rig used for practically all steamers whatever their



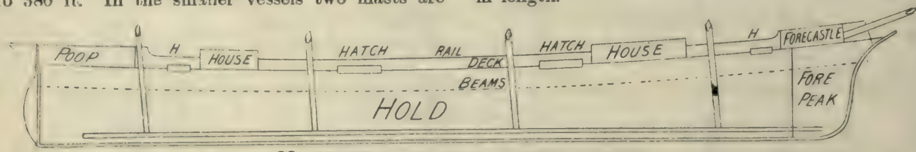
21. FOUR-MASTED BARQUE



22. FULL-RIGGED SHIP

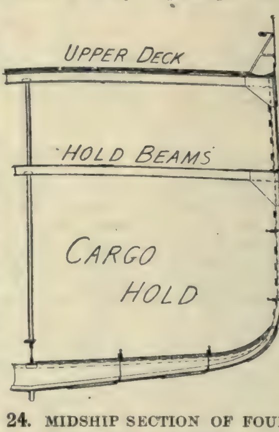
size, if they do carry sails at all. This type of rig is divided into fore-and-aft schooners and ordinary schooners. The former variety has no yard sails, whereas the latter has. In the fore-and-aft rig

the sails are of the trysail type, and are usually identical in arrangement on all the masts. It is adopted for all sizes of ships from 80 ft. in length to 380 ft. In the smaller vessels two masts are fitted as shown by **14**, and in the larger ones as many as seven [**15**]. This rig is particularly favoured in America. The ordinary schooner rig is shown by **16**, and will be seen to consist of a foremast with yard topsail and topgallant sail, but a trysail instead of the lower yard sail, and a mainmast with trysail and topsail only. This is the usual arrangement, but sometimes there are yard top and topgallant sails on the mainmast also. As in the case of fore-and-aft rigged schooners, more than two masts may be fitted when the foremast only is usually fitted with yards. The lengths of ships with this type of rig may be said to range from 90 ft. upwards. The *brigantine rig* [**17**] is practically the ordinary schooner rig, except that a lower yard sail is fitted to the foremast instead of a trysail. On the sketch are also shown double yard topsails and a topgallant and royal sail, but this is not characteristic of this type and could also have been adopted in the schooner rig. The brigantine rig is used in vessels of 100 to 130 ft. in length. It is applicable only to ships with two masts, and is very rarely adopted now. The *brig* is another rare type of sailing ship. This rig is also applicable only to vessels with two masts, and 110 to 140 ft. in length. Fig. **18** shows that it is practically the brigantine rig with yards fitted on the mainmast, so that its sail arrangement becomes similar to that of the foremast. The *barquentine rig* is sometimes adopted for three-masted vessels of about 130 to 170 ft. in length. Figure **19** shows that it is similar to that of the brigantine with a mizzen-mast added. The *barque* is by far the most popular rig for modern sailing vessels, and is applied to ships from 150 ft. in length and upwards. This type of rig requires at least three masts, and is similar to the barquentine, except that yard sails are fitted on the mainmast as well as on the foremast. Figure **20** shows the three-masted type of this rig as it is applied to the great majority of steel ships of moderate size, say from 230 to 270 ft. in length. Figure **21** represents the four-masted barque rig, which is used for nearly all larger sailing vessels, say from 260 to 310 ft. in length. There have been a few five-masted barques in cases of vessels of upwards of 360 ft. in length. A *full-rigged ship* is shown in **22**. This form of rig has been more adopted as a standard than as the actual rig of ships. It must have at least three masts, and it will be seen that it is similar to the barque rig with yards fitted to the mizzen-mast, so that all the masts carry this form of spar. The yards shown in the illustration are, from below—the lower yard, the lower topsail yard, the upper topsail yard, the lower topgallant yard, the upper topgallant yard, and the royal yard. There have been a few four-masted full-rigged ships; and there is one five-masted, 400 ft. in length.



23. PROFILE OF FOUR-MASTED BARQUE

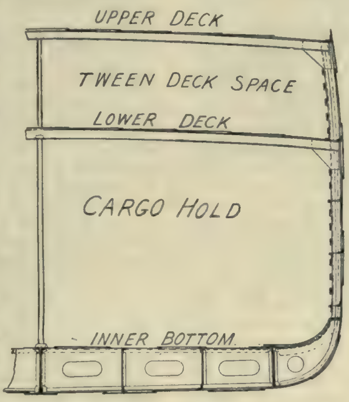
General Arrangement of Ships. Although the sailing vessel is now rarely built, it may conveniently be dealt with first on account of its greater simplicity in general arrangement. Figures **23** and **24** show the outline profile and the midship section respectively of an ordinary large modern four-masted barque, which may be taken as typical in general arrangement for all sailing ships, except in regard to the number of masts. The length of such vessels is from ten to twelve times their depth, and the breadth is from 1·6 to 1·8 times the depth. They consist practically of one huge receptacle for cargo. A few feet from the fore end a watertight bulkhead is fitted for safety in case of collision. But from this point to the after end, or stern, there is but one large hold, as shown by the elevation section or profile [**23**]. In the vertical direction the hold is sometimes divided by a lower deck 7 to 8 ft. below the upper deck, though more often only a tier of beams is fitted at this place. The construction of steel sailing ships is as simple in principle as their general arrangement. These vessels consist of a steel shell ranging from $\frac{5}{16}$ in. in thickness in the smallest sizes to $\frac{5}{8}$ in. in the largest ones. This comparatively thin plating is stiffened in the bottom by deep ribs called *floors*, as shown by **24**. They consist of plates $\frac{1}{4}$ to $\frac{1}{2}$ in. in thickness and from 6 to 30 in. in depth in the smallest and largest vessels respectively. The side plating is stiffened by frame girders [**24**], which form the continuation of the floors. They range in depth from 3 to 6 in., and may be formed of various rolled steel sections.



24. MIDSHIP SECTION OF FOUR-MASTED BARQUE

Details of Construction. At the top of the vessel the frames on the two sides are joined by the beams of the upper deck, which may or may not be fitted with steel plating, but are nearly always covered with wood planking from 3 to 4 in. in thickness. The beams themselves may be of various sections of rolled steel girders. If a lower deck is fitted, as is the case in all large sailing ships, it is similar to the upper deck. Both tiers of beams are supported at the middle of the ship by solid round iron pillars stepping on the centre keelson, which is a large girder formed of plates and angles on the top of the floor plates, as shown by **24**. If the vessel is very broad, there may be additional rows of deck supports called *quarter pillars* fitted between the middle and the side of the ship. The bottom of the vessel is usually fitted with a bar keel, ranging in size from 5 by $1\frac{1}{2}$ in. to 12 by $3\frac{1}{2}$ in., and terminating aft in the stern-post and forward in the stem, both of which are of about the same size

as the keel. To distribute the effect of concentrated loads, girders are fitted on the top of the floors, where they are called *side* and *bilge keelsons*, and on the inside of the frames, where they are called *hold* or *side* stringers. On the top of the upper decks of sailing ships a forecastle is usually fitted. It is an erection at the fore end of the ship about 7 ft. in height. A poop, which is a similar erection at the after end, is also usual. In addition, there may be deck houses for the accommodation of the crew near the midships part of the vessel. In a few instances a bridge has been fitted, which is a midship structure similar to those formed at the ends by the poop and forecastle. Poops, bridges, and forecastles extend always to the side of the ships, so that their side plating is the continuation of the outside plating proper. They are sometimes used for cargo, but more often for living accommodation.

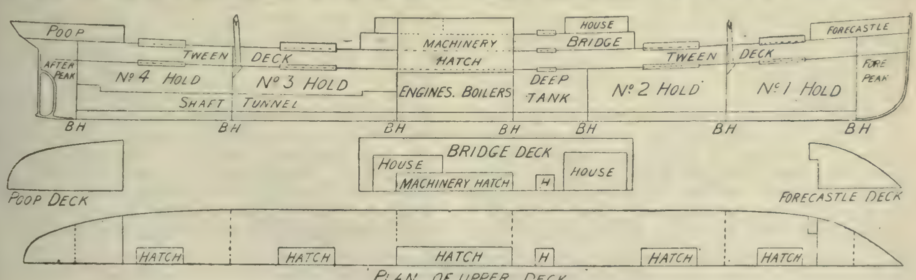


25. SECTION AMIDSHIPS OF A CARGO STEAMER

Arrangement of Steamers. The general arrangement of steamers is somewhat more complicated and more variable than that of sailing vessels. Steamships are, as a rule, relatively longer than those propelled by sail, the length being usually equal to eleven to thirteen times the depth. The breadth is from 1·4 to 2·0 times the depth. A bulkhead is always fitted near the fore end as in the case of sailing ships. The remainder of the ship is not, however, available entirely for cargo, but must also provide space for the propelling machinery and for the coal. It is usual to place the engines and boilers near the midship part of the vessel, as shown by **26**, but sometimes they are placed at the after end, particularly in small steamers, which may thereby obtain one large hold for the reception of cargo. Wherever the machinery space is, it is separated by means of steel water-tight bulkheads from the remainder of the vessel. If the machinery is amidships it is necessary in screw steamers to provide a tunnel through which the propeller shaft passes to the after end of the vessel, where the screw is fitted immediately forward of the rudder. Watertight bulkheads are a source of safety to any ship, as they tend to minimise the effect of a leak by confining the space to which the water gets access.

A steamer would be as safe as a sailing ship with the same number of bulkheads, but as the former is the more valuable, she is always subdivided to a greater extent than the latter. Figure **26** shows a steamer with seven watertight bulkheads, which is the usual for vessels over 350 ft. in length. Shorter steamers have fewer, and larger ones may have more watertight divisions than in this instance. The bottom of a steamer may be constructed, as in the case of the sailing ship shown in **24**, of a single thickness of plating. If the vessel is at all of a fair size, it is now almost invariably constructed with an inner bottom, as shown by **25**. This is another reason why a steamer is usually safer than a sailing vessel. The latter may, however, and sometimes does, possess this source of safety. From **26** it will be seen that the space provided in a steamer is divided up into several holds numbered from the fore end. These, again, may be divided by one or more decks. In **26**, only an upper and a lower deck are shown. As the engines and boilers do not occupy the entire space from side to side of the ship, it is usual to provide bunkers here for the coal to be used on the voyage. If enough space is not available here, the cargo hold immediately in front of the boilers is encroached on for this purpose.

Deck Erections. The character of the upper part of a steamer varies considerably. The top deck may be what is called *flush*—that is, without any erections except casings covering the engine and boiler room openings, and smaller deck houses, such as chart and steering houses. The uppermost deck may also have a poop and a forecastle above it, as in most sailing vessels, or one only of these erections may be fitted, but the most common arrangement is that a poop and a forecastle is fitted at the after and fore end of the vessel as shown by **26**, and a bridge over the midships portion. The bridge is not merely a convenient place for the necessary cabin accommodation in a steamer, but it adds to the safety of the vessel by protecting the large machinery openings from the sea. It is very common for poops, bridges and forecastles to be extended so that there is only a short space between them, which is then called a *well*. In some instances the erections join and form a complete upper structure. The vessel is then called an *awning* or *shelter-deck* steamer, the upper deck being the awning or shelter deck. Above this deck there may possibly be



26. GENERAL PROFILE OF A SMALL STEAMER

other erections. Most sailing ships, if they have to carry ballast, must use stone, sand or gravel. Steamers now always use water for this purpose, as, where the power is at hand it is much more easily let in and discharged by means of filling pipes and pumps. Where a double bottom is fitted, it can be used for the purpose of carrying water ballast. Where the amount thus provided for is insufficient, and where there is no double bottom, the necessary space is provided by a so-called *deep tank*, which is simply a small hold set apart for this purpose, but which may be used for cargo or coal when required. Figure **26** shows one such deep tank immediately in front of the boiler hold. Large steamers may have two deep tanks.

Construction of Steamers. In construction, as in general arrangement, steamers differ more than sailing ships. The outside shell plating is similar in both types. On the whole there is no variation at all in the arrangement of this part of a ship's structure. It consists of individual plates of smaller or larger sizes fitted in a fore-and-aft direction, and as steamers are built of very much larger dimensions than sailing vessels, its thickness ranges from $\frac{5}{16}$ in. in the smallest to 1 in. in the largest ships. The single bottoms of steamers are constructed similarly to those of sailing ships shown by **24**. If an inner bottom is fitted, the floor plates are deeper and thinner, and are lightened by large holes being cut in them as indicated by **25**. The greater depth is required to allow of sufficient space between the two bottoms for every part of the structure to be accessible, and to produce sufficient capacity for water ballast. The inner bottom is fitted on the top of the floors, and consists of plating $\frac{1}{8}$ in. to $\frac{1}{4}$ in. thinner than the corresponding outside plating. At the side of the vessel where the inner bottom terminates, ordinary frame girders are fitted to stiffen the plating. At the top of the frames the beams of the upper deck tie the two sides of the vessel together, as in sailing ships, but in the arrangement of the structure below this deck there is again considerable variety in steamers. There may be only one huge hold below the upper deck with very strong frame girders at the side, or there may be a lower steel deck as shown in **25**, which supports the sides to such an extent that the frame girders may be of smaller size. There might have been a third and even a fourth tier of beams with decks laid on them. Generally speaking, the number of the decks increases with the size of the vessel, but this is to a large extent a question of convenience. In passenger steamers decks are necessary to provide for cabin accommodation, but in cargo vessels a capacious hold may be required.

Framing and Beams. Where the depth from the bottom to the lowest deck is large, and where, consequently, frame girders of considerable dimensions would be required to support the sides properly, a special arrangement of framing is sometimes adopted, consisting of a few very deep plate frames, called *web frames*, fitted at intervals. The ordinary frames can then be of much smaller dimensions, when they are supported by fore-and-aft girders or stringers from web frame to web frame. The beams or decks are supported by means of pillars from the bottom of the vessel. There is at least one row of these supports, but there may be two or three. In cargo holds it is usually desirable to do with as few of these obstructions as is possible, and they are consequently often fitted at a considerable distance apart in the fore-and-aft direction, and have a girder fitted at their heads for the support of the intermediate beams.

Machinery. The engines and boilers used on board ship differ but little in general principle from those on land. But even in a moderately large steamer the power required to drive her through the water at a reasonable speed is in excess of what is sufficient for land purposes except in very special instances. In the smallest of steamers the indicated horse-power amounts to some hundreds, in a moderately large one it may be some thousands, and in a very large one it may be tens of thousands. As the weight of the engines, boilers and coal has to be carried by the ship at the expense of a similar amount of cargo, it follows that it is doubly desirable that marine engines and boilers should be of the lightest construction consistent with absolute safety, and should be of the most economical design as regards coal consumption. A ship engine must also be able to be governed more completely and quickly than a land engine, owing to the continual changes it may often be necessary to make in the speed of a ship. The type of boiler now almost universally adopted in steamers is that known as the Scotch tubular marine boiler, where the flames from the fire are carried through tubes surrounded by water. In a few instances the so-called water-tube boilers have been adopted in merchant ships. In these the water is in the tubes with the flames playing round them. This type of boiler is much lighter than the ordinary one, but it has not been found so reliable all round.

The engines used in a steamer are almost invariably of the inverted direct-acting surface-condensing description. They may be compound, triple or quadruple expansion in their action. Those belonging to the last category are the most economical as regards coal consumption, the steam being used four times before it is condensed. As the power required becomes larger, the number of boilers is increased in preference to increasing their size. Two is the ordinary number, but in large and fast steamers there may be more than a dozen double-ended boilers. When the engines would be inconveniently large, two propellers are adopted. This may also be done where the size of a single propeller would be too large for the draft of the vessel.

Practical Training. In this and the previous article a rough outline has been given of what a modern ship is like, and of the way in which it arrived at its present state of evolution. Such imparted information must, however, always be a poor substitute for that which is gained by the intending shipbuilder during a practical apprenticeship, when he can become thoroughly familiar with all the details of ships as they are. In the following articles the actual building of ships will be dealt with. In the first instance it will be assumed that it has been mutually agreed between the shipowner and the shipbuilder what the prospective vessel is to be like. In other words, the ship has been designed. Drawings showing the general arrangement, a model showing the form, and a specification setting forth the other details having been decided upon, it remains for the shipbuilder only to produce the desired structure.

Continued

HOW TO PRESERVE FOOD

Cold Storage. Refrigerating Machines. Milk Pasteurisation and Refrigeration. Tinned Foods. Chemical Preservatives

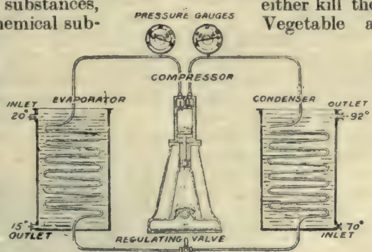
Continued from page 5318

By CLAYTON BEADLE and HENRY P. STEVENS

It is a common matter of everyday experience that most foods, especially those of animal origin, are subject to decomposition if kept beyond a certain period. Before we can properly appreciate the value of the different methods of preserving foods it is absolutely necessary for us to form a clear conception of the causes which bring about decomposition and putrefaction.

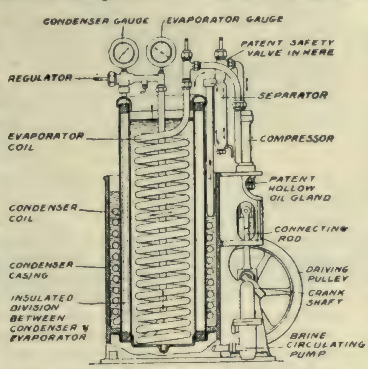
Why Food will not Keep. Foods are mixtures of complex organic substances, and when they go bad these chemical substances undergo chemical changes with the formation of other substances characterised by their unpleasant taste and smell, or by poisonous properties. These chemical changes are brought about by minute organisms (micro-organisms), which are invisible to the naked eye. [See Bacteriology]. All decomposing substances, when examined under the microscope, are seen to be swarming with innumerable organisms of varying shape and form. They are so universal that it is no easy matter to prepare liquids free from them and keep them in this state. Water taken from any pond, well or stream, even fresh rain water, teems with life when examined in this way. Like all living things, these micro-organisms bring about the chemical transformation of matter by "feeding on," or absorbing, substances in one form and excreting them in another, or else producing ferments which bring about these changes. It often happens that substances produced by one organism become the food of another, so that a whole series of chemical changes are brought about. This happens when any animal foodstuff undergoes putrefaction. The danger of consuming such food lies in the small quantities of poisonous products (ptomaines) they may contain. In the early stages of decomposition food is often covered with furry growths, commonly known as moulds. These are well characterised forms of plant life. They are of considerable importance as they prepare the way for the development of other more minute organisms and bacteria. If only we could exclude these organisms, it might be possible to preserve even the most perishable of foods indefinitely.

How Bacteria are Kept in Check. Having shown that food will not keep because of the action of micro-organisms, it will now be our business to inquire into the conditions under which they live, in order that we may learn how to control them. The spores, or seeds, are extremely minute, are always found floating in the air, and are continually settling like dust on every object. Wherever they find favourable conditions and suitable surroundings they quickly obtain a foothold, and breed and multiply. These conditions may be classed under four heads: (1) Supply of suitable food; (2) presence of moisture; (3) suitable conditions of temperature; (4) absence of substances which either kill them or prevent them developing. Vegetable and animal matter, including foods for human consumption, all provide suitable food for micro-organisms, but it is essential for their development that moisture should be present, hence the primitive method of preserving food by drying, and therefore excluding moisture. Thoroughly dried foodstuffs will keep an immense time. The organisms may be there, but have not a chance of developing.



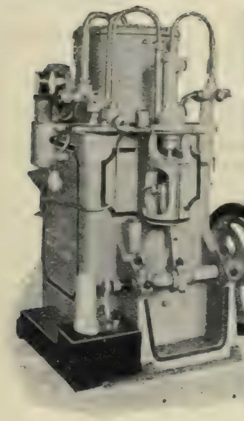
1. REFRIGERATING MACHINE
[Diagrammatic view]

Cold Storage. Food may be preserved by taking advantage of the fact that bacteria will only develop within a certain range of temperature. Thus below about 50° F. their activity is almost entirely arrested; above 170° F. bacteria are destroyed. We shall confine our attention, to start with, to those methods of preservation dependent upon low temperatures, and generally known as refrigeration, or cold storage. The food, whether meat, fish, vegetables, or fruit, is kept at a low temperature until required for consumption. This is perhaps the best method of preserving food as it adds nothing to and takes nothing from the article, so that no change is brought about, and the food remains as nutritious and digestible as before treatment. The advantages of cold storage will become apparent when we see some of the disadvantages attached to the other methods of preserving food. By the aid of cold storage hundreds of thousands of tons of different foodstuffs are imported annually into this country without the use of any chemical preservative. When the ship arrives here the foodstuffs are taken out of the refrigerating chambers, and placed in cold stores until required. We shall now describe the machinery and plant used in this connection.



2. SECTION OF A LAND TYPE OF REFRIGERATING MACHINE

Refrigerating Machines. The rooms in which foodstuffs are stored are generally kept cool by a system of overhead pipes through which cooled brine circulates. Brine is chosen, as it can be reduced to a low temperature without freezing. In



3. LAND TYPE OF CARBONIC ANHYDRIDE REFRIGERATING MACHINE

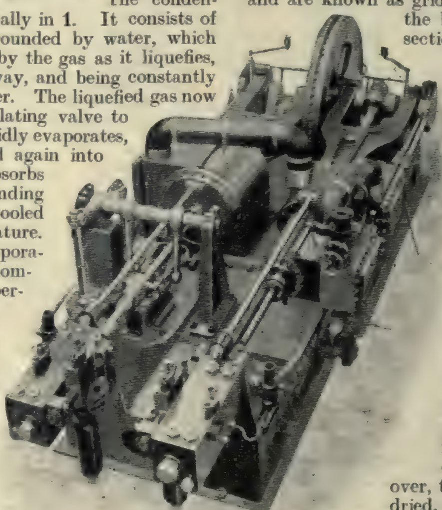
order to cool this brine refrigerating machines are required, of which there are several types, and although those now generally employed are identical in principle, their construction varies considerably. The principle involved is as follows:

By means of a compressor, certain easily liquefied gases, such as carbon dioxide, ammonia, or sulphur dioxide, are condensed to a liquid in a condenser. The condenser is shown diagrammatically in **1**. It consists of a long coil of tubing surrounded by water, which absorbs the heat given out by the gas as it liquefies, the warm water passing away, and being constantly replaced by fresh, cold water. The liquefied gas now passes on through a regulating valve to the evaporator, where it rapidly evaporates, the liquid being converted again into vapour; in doing this it absorbs heat from the brine surrounding it, so that the latter is cooled down to a low temperature. The gas, as it leaves the evaporator, passes again to the compressor, and the cycle of operations is repeated. Provided there are no leaks, no fresh gas is required, since it is used over and over again.

The Chief Gases Employed. Opinions differ as to the most suitable gas, but we may mention three which can be used—namely, carbon dioxide (carbonic anhydride), ammonia, and sulphur dioxide gases. Carbon dioxide gas is cheap, costing only a few pence per pound. On the other hand, ammonia has the advantage that it is liquefied at a lower pressure. While carbon dioxide requires, in temperate climates, a pressure of 850 lb. per square inch for liquefaction, ammonia may be worked at a moderate pressure of about 120 lb. to the square inch. On the other hand, all compressor parts of the carbonic acid plant are much smaller. Ammonia is an alkaline gas, and in the presence of air will dissolve copper and other metals, so that in ammonia machines all copper, or copper alloy, must be avoided in any parts which come in contact with the ammonia. This is a great drawback to the use of ammonia machines where only sea-water is available for cooling, as the iron pipes, which alone can be used, are quickly corroded by sea-water. If it should escape, the smell is objectionable, though scarcely unpleasant, and in case of a serious escape it would prove dangerous. Sulphur dioxide is, perhaps, the least suitable of all three. It is not difficult to liquefy, but is more corrosive, especially as it is liable to be converted, by oxidation, to sulphuric acid in the presence of air and moisture.

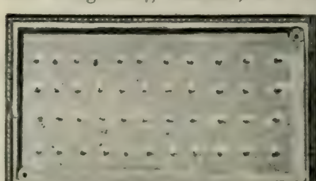
In connection with cold storage we shall describe machines worked with carbon dioxide gas, but will treat of a machine using ammonia gas when dealing with the cooling of pasteurised milk.

Cold Storage Chambers. Figure **2** shows, in section, the construction of a carbonic anhydride refrigerating machine. Fig. **3** is an illustration of this machine, which, of course, can be used not only for cooling brine for cold storage chambers, but also for making ice, cooling water, or all purposes combined. It will be seen, as illustrated in **1**, that the compressor forces the gas into the coils of the condenser, which are contained in an annular vessel surrounding the evaporator, a space fitted with an insulating material being left between the two. The crank shaft not only works the compressor, but also a small pump, which drives the cooled brine from the inner vessel, and causes it to circulate through the pipes in the cold storage rooms. These brine tubes are made in long lengths, sometimes 200 ft., electrically welded, and are known as grids [**6**]. In large installations, the brine grids are divided into sections, each section having a separate return pipe back to the machine, where valves are placed for regulating the quantity of cold brine circulating in each section as required by the temperature in the room: a system of this kind is necessary in order to obtain a regular temperature in the cold stores. The grids are generally fixed at the top of each room under the ceiling, and, the air in contact with the pipes becoming colder, and consequently heavier, descends, and is replaced by "less cold" air from beneath, producing a constant circulation. Moreover, the air is not only cooled but dried, as the moisture separates out, and condenses on the grids. The quantity of cooled brine contained in the system of grids is very considerable, and this acts as a reservoir of "cold," so that in many cases it is unnecessary to run the refrigerating machine continually, but only for a few hours daily.



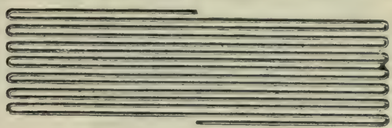
4. MARINE TYPE OF CARBONIC ANHYDRIDE REFRIGERATING MACHINE

In some cases, especially when storing butter above 32° F, and all kinds of fruit, a circulation of cold air is preferable for cooling the chambers, in which case a number of grids are placed together in convenient proximity to the refrigerating machine, and air is drawn through them by means of a powerful fan, and conducted by means of air ducts to the cold rooms. In some meat-freezing



5. BRINE WALL

works it is the practice to install brine walls, which consist of large, flat, very shallow boxes [5] made of steel plates placed parallel to each other at convenient distances, through which the cool brine is circulated. In the passages between these walls the meat to be frozen or chilled is hung, as illustrated in **7**. The brine grids are seen beneath the ceiling, and the brine walls between the rows of carcases. In the rooms overhead, fitted with brine grids, the frozen meat is stored. The brine system is also largely used for bacon curing. The sides of bacon are hung up in rooms chilled by brine pipes, and generally with cold air circulation to 40° F., which temperature minimises the tendency to putrefaction, while, on the other hand, it is the lowest temperature at which the meat will "take" the salt perfectly. Fruit can also be very advantageously stored in cool chambers, either for carriage over long distances, or to keep back a glut until a time at which it will fetch a considerably enhanced price.

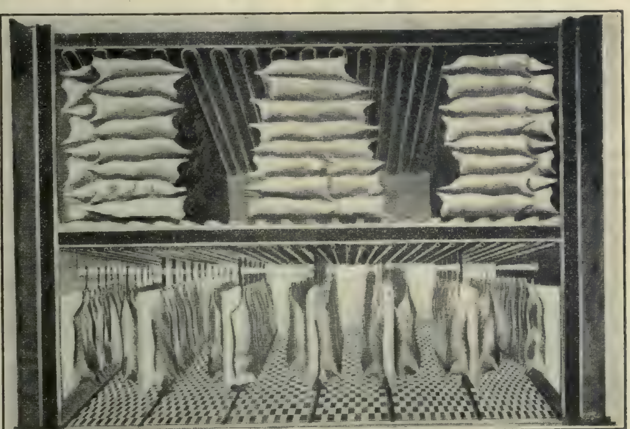


6. BRINE GRID

Refrigeration in Factories. Another instance in which refrigeration may usefully be applied is in cooling chocolate, in order to hasten and facilitate the removal of the tablets from the moulds. This is a very difficult operation in summer under ordinary conditions, when the chocolate tends to adhere to the moulds, making it necessary sometimes to remelt and cast again.

Brewing is a delicate operation depending on the growth of yeast, which is much influenced by temperature. A refrigerating machine is therefore of great importance in a brewery, where it is used to cool a large quantity of water for refrigerating the "wort" and maintaining the correct temperature in the "tuns." Moreover, the finished beer should be bottled at a low temperature.

Multifarious as are the uses of cold storage on land, it is, if possible, of greater importance in the shipping of frozen meat from our Colonies. For such purposes large marine-type machines are employed, as shown in **4**, while for preserving passengers' provisions the machines illustrated in **8** are used. The principle in all these machines is similar to that already described. Figure **9** shows a typical installation for the carriage of frozen meat on board a White Star vessel, on the system of Messrs. J. & E. Hall, Ltd., to whom we are indebted for illustrations **1-9**.



7. BRINE WALL SYSTEM OF FREEZING AND CHILLING MEAT

Preservation of Milk. We now come to another important application of the principle of refrigeration—the treatment of milk. There are very few substances which are commonly used for human consumption so susceptible to the action of bacteria as milk and cream. The rapid decay of these substances, which is commonly and popularly called "souring," is caused by the presence of micro-organisms. It is well known that "souring" goes on much more quickly in warm weather than in cooler weather, and it is likewise known that milk can be kept from turning for certain periods by being put "on ice," or in an ice safe. It is, of course, simply a case of arrested growth of bacteria; the organisms themselves are not destroyed by this action.

Pasteurisation. The process of pasteurisation, which may appear to be rather mysterious to persons not familiar with it, is a comparatively simple operation. In reality, it is a process of heating the milk or cream to a temperature that will destroy the disease germs and chilling it at once in order to prevent the spores from germinating and setting up another generation of micro-organisms. The rapidity with which these spores develop is astonishing, and the practical way of dealing with milk is to deal with it as quickly as possible after being taken from the cow, chill it down at once, and keep it at a low temperature. [See AGRICULTURE, pages 4036-7 and 4209.]

Public opinion, combined with legal necessity, fixes the standard which the practical dairyman must attain, and the demands upon the dairyman are constantly becoming more and more severe.

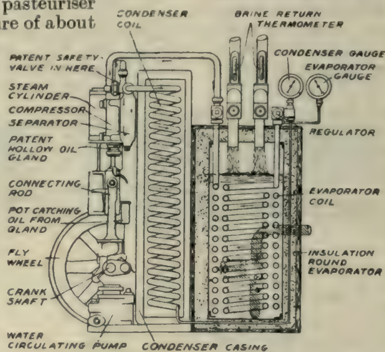
There are, of course, difficulties connected with the process of pasteurisation, and they lie in the accomplishment of the desired result without injuring the milk or changing its consistency, for which machinery properly adapted to the purpose is essential. Properly pasteurised milk has been recommended by the best physicians.

The ordinary pasteuriser which has hitherto been used is shown in **10**, and consists more or less broadly of a vertical cylindrical vessel surrounded by a steam jacket. Within the vessel is placed a vertical spindle having a paddle or stirrer fixed to it, driven by suitable gearing from any source of power. The steam is turned on to the jacket, the milk allowed to flow into the machine, and the paddle set in motion. It is assumed that the whole of the milk becomes pasteurised in being rapidly stirred round and thrown against the steam-jacketed sides of the cylinder. Unfortunately, this assumption is not quite correct, as a portion of the milk does not come into contact with the heated sides of the cylinder, and passes away through the outlet without having

been raised to the requisite temperature to destroy the micro-organisms.

On the other hand, much of the milk is heated to too high a point, and coagulation of the albumen results, impairing the digestibility of the milk. Although the outflow from the pasteuriser may give the correct temperature of about 165°, it will be evident that some of the milk has been heated too much, and some insufficiently heated.

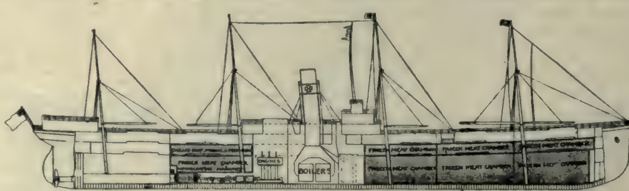
It should be mentioned that another drawback connected with the vertical pasteuriser with revolving spindle is that the step or joint upon or through which the spindle is situated forms a pocket where a little liquid is likely to remain, providing an ideal habitat for bacteria.



8. SECTION OF MARINE TYPE OF REFRIGERATING MACHINE

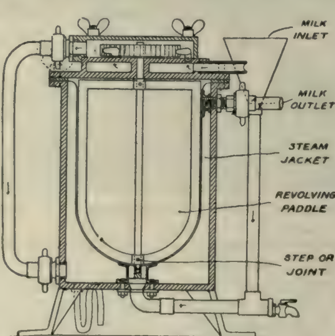
New form of Pasteuriser. In the newer type of machine the milk does not pass through a cylinder, and is not knocked about by a revolving paddle, but flows over a series of revolving drums which are semi-submerged in milk troughs.

In the case of the machine illustrated [11] the milk is allowed to flow slowly into the top trough, in which revolves a tinned copper corrugated drum, through which hot water passes at the requisite temperature. As the drum revolves, a film of milk adheres to it, and is carried over with it and heated to the right point. The outflow from the top trough is taken to a point where the heated milk naturally flows off, and none can go over excepting that which has been brought over by the revolving drum and properly heated. No milk can be overheated, and every particle of milk comes into contact with the drum without being churned or otherwise knocked about. In the second trough is a second revolving drum, through which ordinary water is constantly flowing. This water reduces the temperature of the milk to about 60°, and the milk then flows out into the third trough. A circulation of cold brine at about 35° passes through the third revolving drum, and reduces the milk to about 40°, at which point the milk flows out into a suitable receptacle.



9. SECTION OF A SHIP, SHOWING REFRIGERATING CHAMBERS

In many modern dairies a cold storage room at 38° to 40° is provided, and milk placed in it when it does not go out immediately for consumption.



10. MILK PASTEURISER

The revolving drums are made of hard rolled copper, tinned all over, and the milk troughs, which are round at the bottom, are made of the same material. There is, therefore, nothing that can contaminate the milk, and the revolving drums are thoroughly cleaned after use by being revolved while a brush is held against them, warm water being placed in each trough during the operation. This machine constitutes a pasteurising and chilling apparatus in one frame, but where the older types of pasteurisers are used the milk flows out from them over a flat cooler. These coolers reduce the milk to about 40° as it runs off into the large cans in which it is sent by rail.

The Milk Refrigerating Machine. The next important item to consider in connection with milk pasteurisation and chilling plant is the refrigerating machine, which is necessary to produce brine at a low enough temperature to chill the milk to the requisite point.

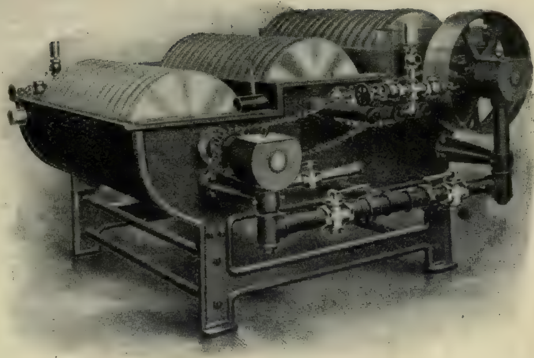
We have already described machines worked with carbon dioxide gas. The one we shall now describe uses ammonia gas [12]. Any escape of gas is prevented by doing away with the reciprocating and compressor rod and stuffing-box, and by carrying the crank shaft horizontally through a self-sealing gland. The principle of refrigerating machines has already been explained. The gas enters at A through the pipe B, and thence into the piston C. D is the suction valve through which the gas passes as the piston descends; then, as it ascends again, the gas is compressed and driven through the passages F and up the discharge pipe F, into the condenser coils, HH, where it is cooled by the surrounding water and liquefied, collecting in a receiver. The liquid then flows to the expansion coils in the cooling apparatus, where it produces the desired refrigerating effect in the action of boiling off to gas again. The ammonia gas thus obtained is returned to the machine to be again liquefied, and the cycle is repeated.

The machine is actuated by the pulley P, attached to the crank shaft L, which revolves in an oil bath and also seals the packing joint M.

In larger machines the condenser is placed apart from the compressor, as plant would otherwise be too bulky and cumbersome. It is built of two tubes, one placed inside the other; through the inner one runs the water which cools the ammonia compressed into the space between it and the outer tube. The construction of the coils is shown in **14**, and **13** is a view of the coil. This form of construction is far superior to the old type, where the ammonia gas was

condensed in a flat coil of pipes, the gas flowing downwards inside the pipe and the water trickling downwards over the outside. The water in this case, being free to evaporate, brought about a certain lowering of temperature; on the other hand, the water getting warm in its descent ran over the bottom pipes when hottest, while the ammonia was endeavouring to liquefy inside these same pipes, with consequent re-evaporation of some of the liquefied ammonia and loss of efficiency.

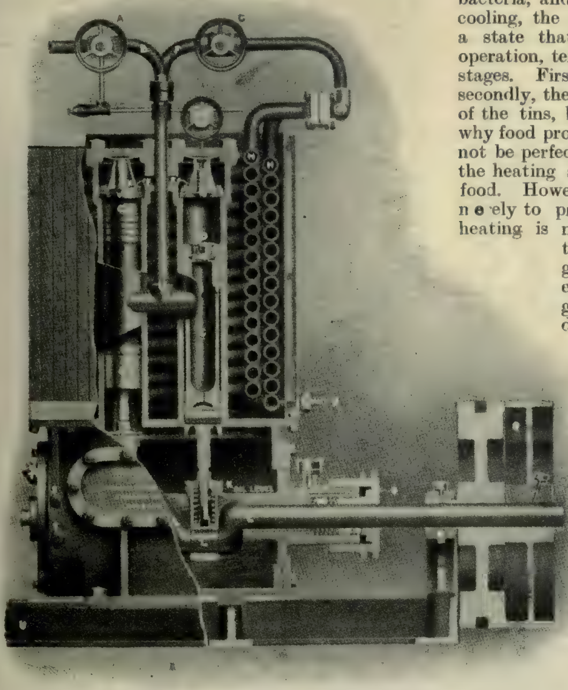
The modern plant for dealing with milk mainly consists, therefore, of an efficient pasteurising machine and a simple and efficient refrigerating machine, with the necessary steam for the heating drum and the power to drive the pulleys on the pasteurising and refrigerating machines.



11. MILK PASTEURISING AND CHILLING APPARATUS
(The covers have been removed)

Removal of Dirt. Owing to the manner in which milk is produced, and at present handled at the farms, it seems almost impossible to exclude dust and dirt. An apparatus which has been lately introduced is a strainer of exceedingly fine mesh having about 1,440 holes to the square inch. Such a fine gauze would be immediately stopped up if it were stationary and the milk simply poured through it. The strainer surface is therefore made in the form of a hoop, and is rotated as the milk flows through it. The rotating gauze hoop is constantly cleaned by a revolving brush, and passes under the milk in an open and clean condition. It is an established proof and fact that milk treated in the above-mentioned manner, properly cleaned, pasteurised and cooled, will keep about 18 hours longer under ordinary conditions than milk which has not been so treated. and it will keep in good condition for from seven to 10 days if placed in a cold room at 30°–40° F. The illustrations **10-14** have been supplied by Messrs. A. G. Enock & Co., Ltd.

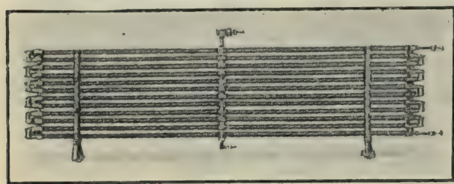
Tinned, Potted, and Bottled Goods. The method adopted in sterilising milk may be applied to numerous other foodstuffs. The principle of the canning process is simply this: The food is heated to about 170° F., in order to destroy bacteria, and the vessel sealed while hot. On cooling, the contents remain sterilised and in such a state that they will keep indefinitely. This operation, termed *processing*, is carried out in three stages. Firstly, the preparation of the foodstuff; secondly, the sterilisation; and, thirdly, the sealing of the tins, bottles, or jars. We know no reason why food properly prepared in this manner should not be perfectly harmless and nutritious, although the heating somewhat alters the character of the food. However, as it is the object of the packer merely to preserve and not to cook the food, the heating is not prolonged more than necessary, twenty minutes to half an hour being generally sufficient. There are, however, certain dangers common to canned goods. In the first place, there is the danger of the acid juices, especially in the case of fruits, having some action on the tin or solder, but cases of poisoning from this cause are very rare, and most of those recorded were probably due to quite another cause—namely, formation of ptomaines. At any rate, the danger can be easily avoided, if there be any, by using earthenware or glass vessels instead of metal ones.



12. AMMONIA REFRIGERATING MACHINE

Ptomaine Poisoning. The chief danger, however, arises from unsound tins, such as "pricked" tins—that is to say, tins in efficiently closed down, or which have been damaged so that the air has gained access to the contents. Tins are sometimes found "blown." This is owing

to incomplete sterilisation, bacterial action setting in after sealing, with the production of gaseous substances, causing a pressure inside the tin. There is always a partial vacuum in sound tins, so that when opened the air rushes in to them with a peculiar sound. If the tin has been imperfectly sealed, or if the sterilisation has not been complete, bacterial action is sure to set in, with the



13. COIL OF DOUBLE-TUBE AMMONIA CONDENSER

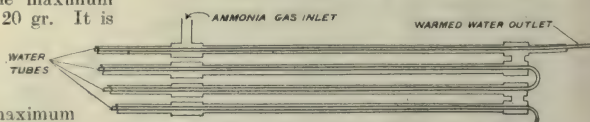
result that the extremely poisonous bodies, ptomaines, are produced. These are the causes of most cases of poisoning from eating tinned goods, especially tinned meat and fish, which are particularly liable to undergo such putrefactive changes. Sometimes, in the preliminary treatment, the foodstuff is treated with chemical preservatives in order to cover defective canning. This practice is to be condemned unhesitatingly, for if the canning be efficiently carried out there is no need for such preservatives. Chemical preservatives are, however, used very largely in food not destined to be canned, especially such as easily undergoes decomposition and putrefaction. We shall have to consider these chemical preservatives somewhat in detail.

Preservatives in Common Use. Common salt is about the oldest preservative we know of, but at the same time it is very ineffectual. In most cases large quantities are required. Where used it is often supplemented by the addition of some powerful preservative. Of chemical preservatives, borax and boracic acid are perhaps more commonly employed than any others. They are, however, very mild in their action, and the quantity used must not be too small. Numerous experiments have shown that less than 4 gr. to the pint is practically useless in preserving milk, and the quantity often recommended to be added is quite double this. Borax and boracic acid are also used largely for butter, cream, potted meat, and many other foods, and the question naturally arises whether they are harmful, and whether restrictions should be put upon their use. Boracic acid is frequently administered medicinally, the maximum dose being 15 gr.; that of borax is 20 gr. It is evident, therefore, that in the case of young children and invalids, who practically live on milk, the quantity taken daily, even putting it so low as 4 gr. to the pint, would exceed the maximum pharmaceutical dose. Such cases illustrate the danger which may attend its use. On the other hand, it is difficult to say how far it would affect a healthy adult, although the recent elaborate experiments of Dr. Wiley seemed to show that even in that case it is likely to prove harmful. Nor can it be claimed that its use is necessary, as some of the largest wholesale dairymen bring their milk to London and other large towns from great distances, and manage to dispose of it without the use of any preservative whatever. Much the same considerations apply to butter, but we must bear in mind that it is not consumed to the same extent as milk by infants and invalids; and as to cream, the great difficulties in the way of preserving cream, even for a short while in the hot weather, makes the use of a preservative pardonable. There is, however, no need for the use of any preservative in the case of meat or fish, which should be kept fresh by cold storage or other means.

Preservatives to be Avoided. Passing now to *formaline*, another preservative, we are on somewhat different ground. No one can assert that formaline is harmless, and its use as a preservative should be prohibited. Nevertheless, it is occasionally found in milk, and is sometimes sprayed over meat, fish, and fruit to preserve them. It has a peculiar action on the gelatinous constituents of foods, hardening them and rendering them insoluble, and thus very difficult to digest. *Salicylic acid* is another preservative, found especially in preserved fruits, temperance beverages, sacramental wines, lager beer, etc. It is probably more dangerous than borax, and its use is seldom, if ever, justified. People differ very much in their susceptibility to salicylic acid. Many people—according to some authorities, 60 per cent.—are easily affected by small doses of the drug, causing symptoms known as salicylism, including deafness, headache, delirium, etc. The use of salicylic acid in food should, therefore, be regarded with great suspicion. *Sodium sulphite* is another chemical preservative which is occasionally found, especially in stale meat, as it has the peculiar property of imparting the bright red colour of fresh meat. It also acts as a deodorant, and masks the offensive odours which are produced in the first stages of putrefaction. *Fluorides*, usually sodium or potassium fluoride, have been found in butter, and their use should be prohibited.

Frauds on the Public. With regard to all these chemical preservatives, the weaker ones, in small quantities, are not of very great value, and the stronger ones are dangerous. Moreover, their use must be regarded as a fraud upon the public, as they impart to the foodstuffs a deceptive appearance of freshness. Thus borax or boracic acid, although they have a certain inhibitory power on the micro-organisms, which bring about the souring of milk, probably have little or no effect on the more dangerous pathogenic bacteria, so that milk preserved with borax, although it may appear still fresh and palatable, is, nevertheless, as stale as if it had gone sour.

Unfortunately, legislation, as it affects preservatives, is extremely unsatisfactory in this country. Although the report of the Departmental Commission appointed to deal with this subject made certain recommendations as to what preservatives should be permissible, and in what proportions, these recommendations have not been adopted by the Board of Agriculture, and have consequently remained a dead letter, with the result that conflicting decisions in the courts are the general rule.



14. CONSTRUCTION OF CONDENSER FOR AMMONIA GAS

FOOD PRESERVATION *concluded; followed by* CATERING.

THE CAUSES OF DISEASE

The Cause and Prevention of the Most Common Forms of Disease. How Disease is Spread. Statistics

By Dr. A. T. SCHOFIELD

We have to speak first of the prevention of endemic disease, or diseases that attach themselves to and recur in a place rather than those which spread from person to person by infection, which are called epidemics.

Phthisis. Consumption depends on three things—the soil, the sower, and the seed ; and without these three things the disease does not occur. The soil is the weakened lung tissue, prepared, first, by hereditary tendencies or, secondly, by repeated bronchitis or other lung diseases. The seed is the bacillus of tubercle, the tiny germ to whose ravages the disease is due. The sower is the fatal opportunity when the seed gets so firmly implanted in the lung that it can multiply. All of us are breathing the germs daily without injury. It is only the combination of all these things that produces the disease.

Phthisis does not depend on temperature ; it is common in Greenland, in English cities, and in the West Indies. It does not depend on latitude ; in Norway, Holland, and Italy the death-rate from it is the same—2·5 per 1,000. It destroys native races (Maories and Sandwich Islanders) because they are not accustomed to it, and have developed no resisting power.

Towns such as Rome, Naples, London, Edinburgh, have the same death-rate from it. It is not dependent on humidity ; the Hebrides and Shetlands are very free from it. It is less common in the Navy than in the Army.

It is not prevented by even temperature alone. A combination of variation and dampness favour its spread, as at Alexandria and Port Said. Even and dry climates hinder it, as on the Nile and in Lower Egypt. A damp soil strongly favours the disease, which, however, is at bottom an infectious one, the germs being principally conveyed by the dust of dried sputum of consumptive people.

Where Consumption is Rare. Consumption is rare at high altitudes, and in people who live in the open air. Switzerland has the lowest death-rate from it. It is mostly found in Europe at elevations below 1,500 ft., where its death-rate is 2·15 per 1,000. From 3 ft. to 4,000 ft. it is 1·9. At 5,000 ft. it is only 1·0.

A great predisposing cause is over-crowding and indoor life, with its associations of foul air ; though Mexican and Andean cities, at 7,000 ft. to 13,000 ft. high, although overcrowded, have but little phthisis, and it is rare in the crowded tents of the Bedouin Arabs.

Phthisis is largely influenced by the mode of living, and according to whether one is brought into contact with dusts and foul air.

Of 1,000 deaths among fishermen, 108 are from phthisis ; among grocers, 167 ; among drapers, 301 ; among poulterers, 461 ; among farmers, 103 ; among cutlers, 371 ; among earthenware makers, 473 ; among operatives, 220 ; among woolsorters, 265 ; among coalminers, 126—coal dust is not so injurious as other dusts.

Consumption undoubtedly increases with bad air ; 70 per cent. of the patients at Brompton Hospital have led indoor lives. The increase of consumption is directly in proportion to the density of the population. It is also due to heredity, for from one-third to two-thirds of the children of consumptive parents develop consumption. The breath itself of consumptive people is not probably the source of infection, but the sputa. The disease clings to sick-rooms and confined dwellings. There is a record of nine successive cases in one travelling van.

Is Consumption Preventable? Phthisis is theoretically preventable, but practically its prevention is attended with many difficulties. Since 1861 the death-rate from this disease every five years has decreased as follows : 2·5, 2·4, 2·2, 2·0, 1·8 per 1,000. In 1851–60 it was $\frac{1}{8}$ per 1,000 of all deaths. In 1880-90 it was only $\frac{1}{11}$.

The chief predisposing cause of phthisis is bad, close air. The mortality in huts is two-fifths of that in barracks. Improved ventilation has recently lowered the death-rate.

Cattle suffer from tuberculosis. Infection may be caused by diseased meat or milk, though this has been disputed by Professor Koch. Bacilli are found in the milk of tuberculous cows.

Sanitation alone does not lessen consumption unless it drains and dries the soil. At Stafford it has made no change. Phthisis and damp soils go together. Where the soil has been dried, the mortality from phthisis has lessened to this extent : at Salisbury, 50 per cent. ; at Rugby, 45 per cent. ; Leicester, 30 per cent. ; Bristol, 22 per cent.

In damp soils consumption, bronchitis, rheumatic fever, measles, whooping-cough, and pneumonia flourish.

Scrofula. One variety of this disease is tuberculous. It is common in close, confined, damp, dark rooms.

Rickets. The predisposing causes of rickets are too rapid child-bearing, weak parents, poverty, bad air, bad food, vegetable diet taken too early in life, and an absence of lime salts from the food. It was found in the Zoo that all the young lions developed rickets when they were fed on horseflesh, because the bones were too hard to crunch. When fed on goat's meat, where the bones are softer, the rickets disappeared, because the animals got the lime salts. Other cases are due to foul air, damp, cold cellars and want of sunlight.

Rheumatic Fever. Of cases of rheumatic fever, 27 per cent. are from inherited tendency. It arises from occupation, outdoor work, chills, poverty, and certain cold, damp soils. Damp houses and damp linen are very likely to bring it on. Close air is also bad.

Malaria. An "unhealthy" climate means almost invariably a "malarial" one. It is due to the bite of a mosquito, a species of *anopehles*, found in warm climates, drying marshes, stagnant pools and fen countries. Malaria is thus common when there is much moisture and decomposing vegetation—in old estuaries, alluvial soil, deltas and damp bases of mountain ranges, and freshly-cleared forest lands. It is least common in winter. The mosquitos are carried by winds across plains. A forest is a great protection, so is a large sheet of clear water, and a dry subsoil and good drainage.

We now turn to the consideration of the prevention of epidemics. With regard to these, the old terms "miasma," "contagion," "infection," have either disappeared or have been modified in their meaning since the discovery of the micro-organisms, which are the invariable cause.

The means of infection are practically by air, water, food, and clothing. In this case again, as in consumption, we require the soil, the sower, and the seed. Epidemics are most common in spring and autumn. They may be divided into *pandemics*, or those which seem to spread everywhere at once, such as influenza (at certain times), and *epidemics proper*, or those which ravage districts.

Those borne by water are typhoid, cholera, dysentery, diarrhœa, and sometimes scarlet fever. All the rest are carried by air, especially smallpox, chicken-pox, scarlet fever, typhus fever, measles, German measles, whooping-cough, mumps, diphtheria, and tuberculosis. Ague, leprosy, plague, typhus fever, are more or less extinct in England.

Cholera. Cholera is believed to be due to the "comma" bacillus, or perhaps to two varieties. The incubation is from one to fifteen days, generally two to five. It is a specific, zymotic, epidemic disease—a filth disease, carried by filthy people to filthy places; but filth alone cannot produce it. It is endemic in Lower Bengal and Central Asia. It is most fatal among negroes. It is commonest in autumn, and reappears in spring. Winter stops it. Infants are exempt from it. It is most common between the ages of 20 and 30. Poverty tends to increase it. It infects by the evacuations, which increase in virulence for three days. There are four stages: (1) *Invasion* and diarrhœa; (2) *exacerbation*, and subnormal temperature starts; (3) *collapse*, and the body drained of fluid; (4) *reaction*, and rise of temperature and recovery. Fifty per cent. of those attacked die in about 30 hours. All stools should be *buried*. Bacilli remain active in the body eleven days after death. All bodies, therefore, should be soaked in carbolic.

Cholera cannot be stopped by quarantine, and is not due to air waves. We eat it and drink it; we cannot "catch" it—that is, through the air. Epidemics occurred in this country in 1831, 1848, 1854, 1866, 1892. It is brought from the Ganges by pilgrims and caravans, and used to take three years to come. Now, by trains and steamers, it can arrive in three months.

The Holy Well at Mecca is a great centre, where pilgrims suffering from it wash and then drink the water. Some 38,000 die each year. At Hamburg, the Elbe has been found swarming with it; in the River Durance, 300 germs per cubic centimetre were found before the river entered the town, and 4,000 after; for on its banks were 20 corn mills using grain from Russia and India, where it had been trodden out by cholera-stricken natives. In 1866, a man landed at Southampton; he came to London, his evacuations passed into the River Lea, which is used as drinking water, and caused 16,000 deaths.

There are three lines of defence against this disease: Isolation at ports of all infected people and articles, the Metropolitan Asylum Board Hospitals, and the action of the Town and District Councils and Medical Officers of Health. The chief object in a cholera epidemic is prevention rather than cure. The sick should have beds of straw, which should be burned. All diarrhœa should be checked, and little fruit eaten, and only fresh-boiled fluids drunk.

Smallpox. The smallpox rash appears on the third day; there are 14 days previously of incubation. The rash begins with red pimples, which then fill with water (vesicles), and then with matter (pustules). There is a pain in the back, and the infection lasts four weeks. Smallpox hospitals tend to infect houses round them. The smallpox infection is doubled in houses a quarter of a mile off compared with those half a mile away. The germs are diffused in fine dust, and have great resisting power to heat and cold, and are spread by clothes more readily than scarlet fever.

MEAN ANNUAL DEATHS FROM SMALLPOX

	At all ages.	0–5	5–10	15–25	25–45
Vaccination optional ..	305	1,617	337	109	66
Vaccination compulsory	114	242	120	122	107

Before inoculation was practised there was an epidemic in this country every three years, afterwards every ten. The maximum mortality was at the end of May. When inoculation began, only one-tenth of all attacked died, but the disease spread everywhere, because there was no proper vaccination, but only *inoculation* with the disease itself. In 1838, free vaccination was established, and in 1853 it was made compulsory.

People are thus protected (1) by having had smallpox; (2) by inoculation with smallpox; and (3) by vaccination with cowpox.

Cowpox may be described as a sort of smallpox in the cow. The table given above is of interest.

Vaccination in infancy loses half its protective power at twenty years of age. Isolation is no substitute for vaccination.

Before 1853, the deaths from smallpox were ·4 per 1,000; since 1853 ·2; now, only ·001 of all deaths are due to this disease. This great decrease is in children under ten years of age. At fifteen years of age the death rate increases, because none have now had it in youth, for the vaccination protects them. Revaccination at 15 is not compulsory, but gives immunity for the rest of life.

The following table gives the figures of hospital mortality in 5,000 cases of smallpox among patients of all ages:

	Under 15 yrs. of age	Over 15 yrs. of age
	per cent.	per cent.
Vaccinated with bad marks ..	4	10
,, one good mark	0	6·4
,, two good marks	0	4·6
,, three good marks	0	2·0

Thirty-eight per cent. of the patients who died were unvaccinated.

If unvaccinated, generally 35 per cent. of those attacked die.

If previously vaccinated, 19 per cent. die.
If vaccinated with no mark, 23 ,, ,, ,,
If vaccinated with 1 mark, 7 ,, ,, ,,
If vaccinated with 2 marks, 4 ,, ,, ,,
If vaccinated with 3 marks, 1·5 ,, ,, ,,
If vaccinated with 4 marks, ·5 ,, ,, ,,

If vaccination were now stopped, smallpox would at once become a very fatal disease, being new. At Sheffield, four out of five had it, and two out of five died when there was no vaccination. Smallpox cost the rates from £7 to £11 a case; 5,000 cases cost £43,300 in three months. In 1,572 cases, 30 per cent. of the unvaccinated died, and only 3·5 of those vaccinated.

Before vaccination, the deaths from smallpox were 3,000 per million, now they are 175. At Sheffield, the proportion of deaths among children under ten who were unvaccinated was 480 to 1.

Inoculation (now discontinued) consisted in injecting a diluted smallpox into the body, and with vaccination (cowpox) this is in time to take effect, even if smallpox is in the system, for hydrophobia and smallpox incubate twelve days, and cowpox only eight days; therefore, if smallpox be "caught" on Sunday, vaccination on Tuesday would be effectual. In mild outbreaks, the germ may have become weakened by passing through persons of slight susceptibility.

Typhoid. The mortality in cases of typhoid used to be 33 per cent.; now, about 17 per cent. die in the third week. Children suffer less than adults. There is first about 14 days of ordinary diarrhœa, and then the fever and disease set in. Patients die of perforation, exhaustion, and slow bronchitis. Forty thousand have died in this country in one year, and it is still one of the greatest scourges in the Army. Our precautions against it were very unsuccessful in the Boer War, and compare unfavourably in every way with those of the Japanese Army in the late war. Good nursing is of the utmost importance, but prevention is easier than cure. Typhoid is due to a special germ. There is a similar disease in cows, conveyed by milk.

An outbreak took place in Worthing through leakage from an infected sewer of subsoil water into a well through a fissure. Another outbreak arose from drinking herb beer made in a room where a patient had lain. The infection is from the excreta. The germ does not live long in sewage, nor in rain water; but if nitrites are formed by filtration through the soil, etc., it can live on these for a long time. It abounds in shallow wells.

The general health rate in towns is really determined by the death-rate from typhoid. Of 49 rats inoculated with typhoid, and breathing sewer gas, 37 died; of 49 rats inoculated, and breathing pure air, 3 died; of 72 guinea-pigs inoculated, and breathing sewer gas, 57 died; of 72 guinea-pigs inoculated, and breathing pure air, none died.

Diphtheria. Diphtheria is conveyed through the air at short distances, and is most fatal to patients of from one to ten years, and especially between the ages of three and six. The incubation is one week.

Infants are not exempt, and it attacks both sexes, rich and poor alike. It used to be most common in the country; it is now most common in the town. It began 60 years ago, and is most frequent in winter. It is endemic in Paris and Florence. Diphtheria is due to a specific germ. Darkness, dampness, dirt, ash-pits, appear to favour it, but it is doubtful if it comes from drains. It is caught often by kissing, and is common after scarlet fever; there is also an hereditary tendency.

Where membrane forms, one-third of those attacked used to die before the anti-toxin was used; but the mortality is now much reduced, for protection by anti-toxin is very great, and may reach immunity. In malignant cases patients may die in twenty-four hours. The poison lurks about for weeks afterwards, so that patients must be strictly isolated till all membrane is gone. Ten per cent. of those attacked have slight paralysis after. Cats can take diphtheria, and cows can transmit a similar disease by milk, not by water. Anti-toxin is got from horses kept near Harrow, which, by repeated injections of doses of diphtheritic poison of increasing strength, develop in the serum of their blood so much anti-toxin against diphtheria that they are used as storehouses for it. They are in perfect health and do nothing, but are occasionally blistered, when a small amount of the fluid is drawn off and used. The writer has seen a little girl with her throat and nose filled with thick, white membrane, and a short time after injecting the anti-toxin he has seen it melt away like snow before the sun, and the child, who would have died, recover.

Measles. In measles, the rash appears on the fourth day, and often attacks eyes and ears, and leaves deafness. In adult life it is a serious disease. "Black" measles are dangerous. In countries where it is rare, it is very fatal, but in England we are hardened against it. The

infectious germ is largely carried in the air by sneezing and coughing, also by clothes; but not by water, milk, or animals.

Whooping-cough. Whooping-cough is the most fatal disease for children under five, and is infectious for six weeks.

Chicken-pox. Chicken-pox is usually mild. Fresh crops of spots continue to come out for six days. Incubation lasts fourteen days.

Scarlet Fever. Scarlet fever is most common in children under three. Infection is caught by the breath, or, in the later stages, by bits of infectious skin. The fever can be conveyed by milk from a similar disease in a cow, but is not conveyed by water, or carried far by air currents. Many escape altogether; it is therefore well to protect young children. Over three, they are less susceptible, and it is less dangerous. It is most prevalent in autumn. The incubation is under a week.

Typhus. Typhus is nearly extinct in England. It is carried by the air short distances, and about 18 per cent. of cases are fatal.

The present (lowest) mortality from these diseases per 1,000 per annum is as follows:

Diphtheria	·1	Whooping-cough	·6
Typhoid	·2	Diarrhœa	·6
Measles	·3	Measles	·6
Scarlet fever	·4	Phthisis	1·3

Any death-rate from these diseases which exceeds this should be inquired into at once.

Influenza. Influenza, or the "influence of the stars or weather," is due to a "dumb-bell" bacillus. It is an infectious, contagious disease in the air carried from person to person. The incubation is from two to seven days, and people remain infected one week after the symptoms go. The earliest recorded outbreak occurred as early as the year 887; more recent ones in 1803, 1833, 1837, 1847, 1889, 1891, and since. It occurs at all seasons, and attacks nearly all Europe at once (pandemic). It can travel in one night from Moscow to Vienna.

There are four varieties known—digestive, respiratory, locomotor, and nervous. In 1890, 28,000 died, which shows what an enormous number must have been sick, for the writer has seen hundreds affected, but not one who has died. It caused the death-rate to rise to 46 from 18. It has one-third of the incubation of small-pox; hence, while 10 people are getting small-pox, 1,000 may get influenza. There is no rash, and it is not easily recognised, and it attacks adults freely, because so few are protected. It is like a common cold, but much more severe, and therefore difficult to isolate. One attack, unfortunately, gives but little protection.

Isolation should be practised when old people are exposed to it, and when it is the first case in a new locality. Where it rages large gatherings should be forbidden. All prophylactics, such as camphor, oranges, or drugs, are useless. It is of the first importance to be in generally good health when attacked, and there should be no exposure to cold till recovery is complete. The nervous variety often leaves the mind disturbed, while the respiratory is often accompanied by severe, and sometimes fatal, pneumonia. The digestive and locomotor varieties are less dangerous.

Influenza is supposed to have originated in Eastern China.

Erysipelas. The mortality of this disease, like scarlet fever, is in inverse ratio to the rainfall, for damp checks perspiration, which is so conducive to recovery. It always enters through some wound; the germ cannot penetrate the healthy skin.

Epidemic Infantile Diarrhœa. This is endemic in Preston and Leicester. When the temperature 5 ft. below the surface is 56°, the germs rise, and infection begins. In the first quarter of a year in Leicester there were 27 deaths from it; in the second there were 29; in the third (during July, August, and September) there were 925; in the fourth, 44, showing that it is only in certain seasons that it rages. It abounds in loose, porous, foul, damp, and "made" soils.

The temperature at 4 ft. below the surface determines the activity of the germ, which is increased by stagnant air and bad food, and is most common in poverty, dirt, darkness, and crowded localities.

Less Common Diseases. Continued Fever is a name given to mild forms of some of the specific diseases. Yellow fever appears in the West Indies, Mexico, Brazil, West Africa. The incubation is from one to five days, and lasts from two to three weeks. Relapsing fever is due to a spiral bacteria. There is a sudden onset and sweating for seven days; then, after another seven days, this is repeated. It is common where there is overcrowding and want of food. Anthrax and Woolsorters' Disease and Splenic Fever are closely allied diseases taken from sheep and cattle. Glanders, or farcy, is a nasal discharge, with gland swellings, common in horses, but rare in man. Tetanus, or lockjaw, is a disease of garden soils, where the germ swarms. It is not infectious, and arises from fouling some wound (a cut finger, for instance) with the soil; hence it is commonly "taken" through the hands and feet.

HEALTH *concluded; followed by* ILL-HEALTH

THE STEAM ENGINE

Heat and Steam. Newcomen Engines. Watt's Inventions. The Oldest Steam Engine in the World. Boilers

By JOSEPH G. HORNER

AFTER the invention of the printing press, that of the steam engine has contributed more than any other to develop the civilisation of the human race. Without it the great machines that relieve men of manual toil—the spinning and weaving machines, the lathes, and various metal-shaping machines—would have been undeveloped. The enormous postal service, the ocean steamers, the expresses, would have been unknown. Yet it, together with the vast industries which it has created, was struggling into birth so recently as the period when Dr. Johnson paced his beloved Fleet Street. The men who created the charming literature of the eighteenth century cared nothing for the new agent which was coming into being. Watt enjoyed, perhaps, as much notoriety as any engineer of the period. But Dr. Johnson, when visiting Birmingham, did not think it worth his while to accompany Boswell to see the famous works where about 700 "hands" were employed. The attitude of culture towards mechanical subjects was reflected in Johnson's remark to Boswell in reference to the people of Lichfield. "Sir, we are a city of philosophers; we work with our heads, and make the boobies of Birmingham work for us with their hands." Little notice, therefore, was taken of the work of the engineers. Even the great canals which Brindley had cut for the Duke of Bridgewater were apparently never alluded to by Dr. Johnson. Bramah, Maudslay, and their fellows found no place in contemporary literature. The literary class knew nothing of Cort and Onions—men whose inventions and discoveries profoundly influenced the metallurgy of iron, and through it the civilisation of the present period. Now there are many millions of horse-power of work done daily in the world by the steam engines.

The Power Behind the Engine. Many people are so accustomed to associate the action of steam as such with the power of the engine that they often overlook the essential agent. For steam is but one vehicle of power, one only of several that are possible. The real agent is *heat*, and heat is obtainable apart from steam. We may be pardoned for putting this essential fact in language taken from Herbert Spencer, who began life as an engineer, in which he must have achieved distinction had he not chosen to devote his immense talents to the pursuit of science and philosophy. "The late George Stephenson was one of the first to recognise the fact that the force impelling his locomotive originally emanated from the sun. Step by step we go back from the motion of the piston to the evaporation of the water, thence to the heat evolved during the oxidation of coal; thence to the assimilation of carbon by the plants, of whose imbedded remains coal consists; thence to the carbonic acid from which their carbon was obtained; and thence to the rays of light that deoxidised this carbonic acid. Solar forces, millions of years ago expended on the earth's vegetation, and since locked up beneath its surface, now smelt the metals required for our machines, turn the lathes by which the machines are shaped, work them when put together, and distribute the fabrics they produce."

The Nature of Heat. In the eighteenth century, steam engines were manufactured at a period when utterly false theories prevailed respecting the nature of heat. In the philosophical treatises of that time the term "caloric" occurs constantly, and both steam engines and hot-air engines were long termed *caloric engines.* It was then believed that heat was an imponderable but material and indestructible fluid, which insinuated itself between the pores of bodies, and which possessed gravity; and the term caloric has lingered on, even into the present period. Count Rumford disposed of the old theory by showing experimentally that heat and mechanical work were interchangeable, inasmuch as heat might be produced by work, and work could be done by the application of heat. Heat, therefore, as we all know now, is one of the many forms of energy in the universe, and as such it is measurable in thermal units, representing a definite number of pounds, 772 lifted a foot high, or as kilogrammes, 424 lifted a metre high. Hence the science of heat is termed *thermodynamics*, and the first law of thermodynamics is this—that when work is transformed into heat, or heat into work, the quantity of work is mechanically equivalent to the quantity of heat.

Heat is utilised in various ways—in the steam engine, in the form of aqueous vapour; in the gas and oil engines, in the gaseous products of combustion; in hot-air engines, in the form of atmospheric air subjected to rapid changes of temperature. But in any case mechanical work results only when there is a change from a *higher* to a *lower* temperature, which expresses the second law of thermodynamics. An obvious corollary is that the greater the range between the higher and lower temperatures the greater must be the efficiency of the heat engine. Incidentally, this explains why the pressure of steam and gas employed in engines (and consequently their temperatures) have always been increasing, and continue to do so still.

The Vehicle through which Heat Works. Every one knows that the moving agency in a steam engine is a piston, enclosed in a cylinder, and actuated by the pressure of steam on its opposite sides alternately. So far, so good. But why should steam possess sufficient force to press with a load of many tons at one instant on the piston of a large engine? Steam is a highly heated gaseous fluid, very much hotter than the water from which it is generated. Now, the hotter a gas is, the more active are its molecules. These are incessantly flying to and fro, hammering against one another, and against the sides of any vessel in which they may happen to be contained; and the result, in common language, is not molecular activity, but *pressure.* In actual fact then, since increased heat produces increased activity, driving the molecules farther asunder, the active motive power in the steam engine is heat, and the steam is simply a vehicle for the supply of the heat. One would,

therefore, expect to find that heat other than that of steam would do similar work, and such, in fact, is the case. In fact, from the theoretical point of view, the vehicle utilised may be ignored entirely—*the heat is the essential thing.* For Carnot has shown that if any two temperatures are chosen, a higher and a lower, the efficiency of an engine working between those temperatures depends on the difference in temperatures, and not at all on the substance employed. All reversible engines, therefore, which fulfil this condition have theoretically the same efficiency, irrespective of the working substance which is the agent of temperature changes. Hot air, coal gas, blast furnace gas, producer gas, the vapour of petroleum, are all used to a very large extent, and their resulting action is the same as that of steam, though the method of their utilisation is not precisely the same. Into the relative economies of these we need not enter here. It is sufficient to have established the fact that the steam engine is simply a heat engine, for which steam is just a very convenient vehicle. Actually, there are excellent reasons why some agents are less suitable than others; why heated atmospheric air, for example, is vastly less useful under practical conditions than the vapour of water or the hydrocarbons produced by the combustion of coal or oils.

How to Utilise the Heat of Steam. The first practical point which arises relates to the nature of the vessel in which temperature reduction is to be accomplished with economy. It may consist of one or more vessels. The most familiar type is the cylinder of the steam engine. But a single cylinder is a crude form, because the range of temperature possible in one cylinder is not extensive enough to permit the highest range of expansion which is either desirable or possible when the range is divided between two cylinders (*compound*), three (*triple expansion*), or four cylinders (*quadruple expansion*). The point, therefore, is that the object sought, in order to ensure high efficiency, is to bring the steam (the heat carrier) into the first cylinder at as high a temperature as is practicable, and to cause it to escape (*exhaust*) finally at the lowest temperature that is practically possible. Stated in this way, the problem does not strike one as being very difficult, yet in the growing approximations thereto lies much of the history of the steam engine for the past 150 years.

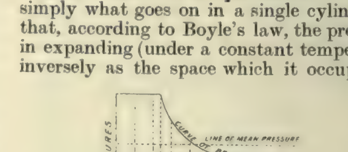
The Meaning of Expansion. The term *expansion* has been employed. The fact which it expresses is inseparably associated with pressure and temperature. From the present point of view it is a property possessed only by gaseous fluids. Solids and liquids expand slightly, but not in the same sense that gases do. Thus, a vessel may be half-filled with a liquid; this will not expand sufficiently to fill the vessel, but raise its temperature sufficiently to convert it into a gas, and the gas will expand and fill the vessel, or another many hundreds of times larger. In the transition from the liquid to the gaseous state, it has received *heat* and expanded; and if it is caused to resume the liquid state by condensation, it will in doing so yield up that heat and shrink back to its former dimensions. A gas cannot be retained and made to do useful work by its expansion in an open vessel, but only in one that is closed and rendered impervious to the passage of the gas. Without this capacity for expansion, the heat absorbed by a gas in passing into the gaseous state would be of no value in the engine. A red-hot mass of metal would be useless as a vehicle of heat energy, because it would be incapable of expansion, and without expansion pressure would not result.

The force exercised by an expanding gas is termed its *elastic force*, and this is the equivalent of *heat energy*. Hence we say that the elastic force of steam is an invariable quantity at a given pressure and temperature. With increase in these, elastic force increases, and consequently the power exerted. So, therefore, by increasing pressure and temperature of steam in a vessel (the *cylinder*) the power of the engine can be multiplied without increasing its dimensions, which fact explains why small engines now give out much more power than large ones formerly did.

We arrive, then, at the fact that in any heat engine the work done is proportional to pressure and temperature, and that the engine does work by reason of the energy manifested as heat, which produces expansion of the heated gas, its vehicle. Pursuing the subject into another stage, let us see what goes on in an engine cylinder to which steam has been admitted.

The Way in which Expansion Takes Place. The pressure of the expanding steam operates against the face of a piston which is free to move along the cylinder, and which is connected by its rod to the rotational mechanism of the engine. If now steam is admitted at one end of the cylinder, it pushes the piston to the other end. And in order to do so the steam may be admitted as long as the piston is moving—that is, throughout its entire stroke. This was the old way, which was extremely wasteful of steam, because its expansive force was not properly utilised. But the steam supply may alternatively be *cut off* at a definite stage, as at one-quarter, one-third, one-half, three-quarters, or seven-eighths of the stroke. This is the modern method, in which the steam is made to do work during the remainder of the stroke by virtue of its expansive energy [**1**]. Or, further, the steam, partly expanded in one cylinder, may be exhausted into a second cylinder to move a piston there by its expansive force, and thence into a third cylinder to move its piston similarly, as in the compound expansion engines.

The Curve of Expansion. But considering simply what goes on in a single cylinder, we know that, according to Boyle's law, the pressure of a gas in expanding (under a constant temperature) varies inversely as the space which it occupies. Though steam (unless superheated) is not a perfect gas, yet for the present purpose it may be regarded as such. If, therefore, steam is admitted into a cylinder during, say, a fourth of the stroke, and then cut off, the curve of pressures will be a falling one, as in **1**. The average of all the ordinates measured in the diagram of work will be the average pressure exerted during the stroke. In other words, the area of the space enclosed by the straight and curved lines shows the amount of work done by the steam during each stroke of the piston.



1. CURVES OF STEAM PRESSURE

The curve of expansion in an engine cylinder does not fulfil Boyle's law, for then it would be an isothermal one, or one of equal temperature, which is impossible. Since a portion of the heat in the gas in expanding becomes converted into mechanical work, the temperature of the gas must fall, for that, as we have seen, is an essential condition of convertibility. But supposing that fresh heat were applied to the steam during its expansion, sufficient to compensate for the heat lost as work, then Boyle's law would hold good, and the curve of expansion would be an *isothermal* one. An approximation to this is secured by the *steam-jacket*—the casing of hot steam which surrounds most engine cylinders. This represents the best condition for general practice. Sufficient heat is imparted thus during expansion to prevent liquefaction of the steam that would otherwise result from the rapid yielding up of its heat. The question of very high pressures and superheating opens up other problems, which may be deferred to a later stage.

The Engine Compared with a Gun. Should there be an initial difficulty in realising the elastic force of steam that is bottled up in a cylinder behind a piston free to move, the subject may be apprehended better from another point of view. If for the cylinder a gun, a charge of gunpowder, and a projectile are substituted, we shall see analogies between the two. The ignition of the gunpowder generates an immense volume of hot gas, the expansion of which, accompanied by pressure, drives out the projectile with much initial energy. The parallel between the gun and the engine cylinder is absolutely complete in its essentials, notwithstanding that the action of the gunpowder is more energetic and rapid than that of the steam. The fact that the steam is produced in a separate generator (the boiler) and the gas is generated within the gun is a matter of detail only. Actually, in the gas engines and petrol engines the explosive gas is generated within the cylinder, hence the term *internal combustion* engines applied to those great groups. But the gun is as truly an internal combustion engine as the gas and petrol motors are.

Early Engines. Having briefly explained the nature of the power behind the engine, the remainder of this article may be occupied with a rapid survey of the epoch-making developments in the history of this group of prime movers.

It is a curious fact that the first engines were not steam engines. To us it seems now so very natural to utilise steam in certain fashions in the engine that these methods seem almost self-evident. But the accomplishment of this is the outcome of as remarkable a story in the history of invention as any in the annals of engineering.

Atmospheric Engines. The first engines, then called *fire engines*, were not driven by steam at all, but by the weight of the atmosphere. The steam was used only because it could be condensed from atmospheric pressure, leaving a moderate vacuum. Papin's engine consisted essentially of a cylinder of metal with an air-tight piston fitting easily therein. The power given out by the engine was developed by the descent of the piston. The piston descended by gravity, and the conditions necessary for descent were fulfilled by the production of a vacuum underneath the piston. But herein lay the impracticable element in Papin's machine. The fire that generated the steam was underneath the metal plate that formed the base of the cylinder, and in order to condense the steam, so that the piston might descend, it was necessary to take the fire away from the plate and to let the cylinder cool. Then, after the descent was accomplished, fresh steam was generated, and a counterbalancing weight lifted the piston to its original position.

Nevertheless, this embodied the first germ of the condensing steam engine, but so utterly impracticable in character that it must have perished in its birth if practical mechanics had not taken it in hand.

Newcomen's Engines. Newcomen and Cawley took up this engine in 1705—after a lapse of 15 years—and, still effecting the descent of the piston by atmospheric pressure and its ascent by a counterpoise, they adopted the more simple and speedy method of refrigerating the steam by introducing cold water round a space contained between the outer surface of the steam cylinder and the inner surface of an enveloping cylinder. Still, this was a slow process, and, though a very great step in advance, would have been insufficient to bring the engine into general use. But luckily, through want of suitable tools, the cylinder could not be bored, and the piston therefore could not be made steam-tight. As a clumsy remedy, a stratum of water was kept above the piston to fill up the open spaces between its circumference and the sides of the cylinder. One of these pistons was observed accidentally to be travelling more rapidly than usual, and on examining into the cause of this increase of speed it was found that water was dropping down the badly-fitted sides and condensing the steam underneath. The hint was taken, and water henceforth was thrown *into* the cylinder instead of *around* it.

Newcomen's pumping engines were all driven by the pressure of the atmosphere upon the upper side of a piston in a cylinder open at the top. A substantial improvement in these was made in producing the steam in a vessel or boiler away from the cylinder, and leading it thence to the latter through a pipe. Time, of course, was saved thereby, but the steam had still to be condensed within the cylinder after having done its work, in order that the pressure of the atmosphere might operate above the piston against the vacuum formed beneath. The atmosphere pressure amounted, of course, to a considerable total over the area of a piston of several feet in diameter, and all these engines were therefore of very large bore. But as it was necessary to get rid of the counter-pressure of the atmosphere against the lower side of the piston, steam was used as a convenient method of producing a vacuum there. In operating these engines steam was first introduced below the piston, displacing the atmosphere, and then condensed by a spray of cold water. The piston was then pushed down by atmospheric pressure opposed to a vacuum. The piston-rod was attached by a chain to one end of a pivoted beam. A chain at the other end lifted the rod of the mine pump. When the stroke was completed, the weight of the pump-rod, made sufficiently heavy to counterbalance the weight of the piston, pulled the latter up to the top of the cylinder, at the same time that steam was being admitted below the piston. Several of these venerable "fire engines" remain in existence to-day, and some are still in operation.

Watt's Inventions. Crude, and even comical, though the arrangements of the Newcomen engine appear to us, it was the only workable type in use until 1769. One of the oldest of these has been in service at Bedminster, Bristol, nearly until the present time. It was in operation in 1900, and was attended to by a man whose father and grandfather lived and died in the service of the same engine. The only

interest which these engines possess now is that they were the primitive types with which Watt was familiar, and the repair of a model of which for Glasgow University—still preserved—led to those researches and inventions by which he designed in nearly all its essentials the modern type of steam engine. The old style of cylinder, with its axis vertical, and the beam were retained; and the functions of the Watt engines were restricted mainly to that of pumping water from mines, thus following the Newcomen engines.

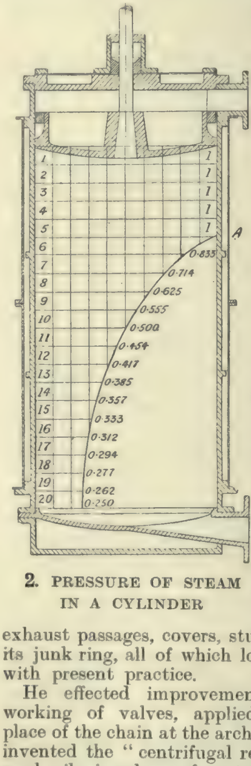
The Separate Condenser. The great and crowning glory of the inventive genius of Watt consisted in an improvement which it is difficult for us in the present day to appreciate fully. It was one of those apparently very trifling improvements which have been fraught with immense consequences. It consisted merely in condensing the steam in a vessel *away* from the cylinder. Watt invented much more, improved in many other ways, but that is the bottom fact in his life's work. So simple was it that his patent was attacked and infringed because of its simplicity, yet so rich in results that it became the basis of wealth to Watt and his partner Boulton, and to many others beside. It gave the death-blow to the old water-wheels and windmills, became a powerful factor in the extinction of the domestic system of manufacture, and in the enormous growth of the factory system, and rendered steam navigation possible. Yet it was merely a vessel for condensation, separate from the cylinder, nothing more.

In the words of the historic patent of January 5th, 1769, "In engines that are to be worked wholly or partially by condensation of steam, the steam is to be condensed in vessels distinct from the steam vessels or cylinders, although occasionally communicating with them; these vessels I call 'Condensers.'" Men's minds run in grooves, out of which only the genius of the great inventors lead them. For a century men had condensed the steam within the cylinder, and only after years of wearing thought and frightful headaches did Watt evolve the idea of the separate condenser, and he tells in one of his letters how the idea came to him while walking one Sunday on the Green of Glasgow. It seems now almost incredible that previous to this more than three-fourths of the steam generated was wasted in condensation in the cylinders, for which there was no remedy until the idea of separate condensation flashed across the mind of Watt. Condensers are used for all engines except those of the locomotive type, and some of the smaller high pressure kinds, jet condensers in many cases, and surface or tubular condensers for marine engines.

The First Steam Engine. Watt also made the first steam engine when he employed the elastic force of steam in place of that of the atmosphere to push the piston down, still, however, creating a vacuum below it by the condensation of steam. This was Watt's *single-acting* engine. Afterwards (1784) he made the first *double-acting* engine, by employing steam pressure alternately on each side of the piston, creating at the same time a vacuum on the side opposite to that against which the pressure was exercised. Thus, the extra weight on one end of the beam required to raise the piston up was abandoned.

The Steam Jacket. Watt applied the first steam jacket, for he clearly understood that the "steam vessel" (the cylinder) must be kept as hot as the steam that enters it, by enclosing it in non-conducting materials, or by surrounding it with steam, or by not allowing water or any other substance colder than steam to enter or come in contact with it. The way to do it was by no means apparent at once. One curious attempt was the following: He observed by experiments with a small model that the cylinder condensation was greater than in an actual engine, and that suggested to him the making of cylinders of bad conduction, wood for example. He made one, therefore, in wood, with a 6-in. bore, and 12-in. stroke, soaked in linseed oil, and baked. This did not answer to his liking.

Other Improvements. He also applied the air-pump to draw out any air present in the condenser, and which would impede the working of the engine. He cut off the steam at part stroke, causing it to work expansively, and took indicator diagrams. Figure 2 is a diagram which formed a portion of Watt's patent of 1782, in which the expansive action of steam is illustrated. The description is too lengthy for quotation, but the diagram shows that steam at atmospheric pressure is admitted to the upper side of the piston for a length of 2 ft. to the point A, in a cylinder 8 ft. in length, and then cut off. The figures in the curve of expansion represent the gradually diminishing pressure of the steam until it reaches the point of exhaustion at 20, where it is one-fourth of the initial pressure. The jacket around the cylinder will be noticed, and also the general arrangements of inlet and exhaust passages, covers, stuffing-box, piston, with its junk ring, all of which look odd by comparison with present practice.



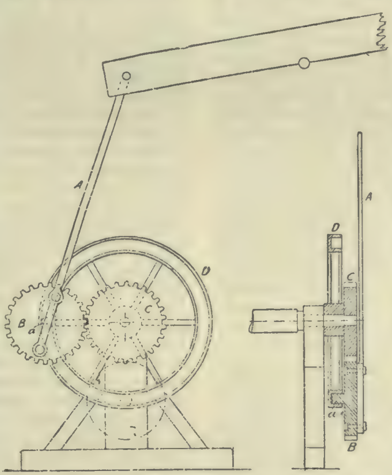
2. PRESSURE OF STEAM IN A CYLINDER

He effected improvements in the automatic working of valves, applied parallel motions in place of the chain at the arch head of the old beams, invented the "centrifugal regulator," or governor, used oils in place of water for lubrication, and designed glands and stuffing-boxes, all of which are embodied and vastly developed in present-day practice.

The First Rotative Engine. But up to 1781 no Watt engine had been made rotative. There was reciprocating motion only; the piston, moving downwards, dragged the pump-rod upwards, and vice versâ. Of course, the crank was known, being as old as the lathe, but its application to the steam engine had already been patented, and so when Watt desired to make rotative engines he devised the famous *sun and planet motion* [3]. This was one only out of half a dozen devices with the same object which were born in his inventive mind. He would have used the crank,

but that his rival Hornblower had patented its application to steam engines. The sun and planet motion is only a mechanical curiosity now. But it must be remembered that before the time of Watt the necessity for rotative engines had not arisen. Almost all the old engines were used for pumping water out of mines; the long rods, or *spears*, were just attached directly to one end of the great beam, and partook of its up and down motion.

It was in 1781 that Watt took out the patent for converting the reciprocating into rotary motion to the wheels of mills or other machines by means of the sun and planet motion, an ingenious device long since superseded by the crank. An engine fitted thus [3] is at South Kensington. The place of the pump rod at the end of the beam was taken by a connecting rod, A, at the lower end of which a cog-wheel, B (the planet wheel), was fixed, so that it could not turn. Its teeth engaged with those of another wheel, C, a sun wheel, fixed on the shaft of the wheel D, free to rotate and made to rotate by the movement of the planet wheel around it. A pin, *a*, projecting from the back of the planet wheel, and guided by a groove in D maintained the toothed wheels in contact. Later came the crank as we now know it, and with this last improvement Watt left the beam engine essentially as it exists to-day. Watt and his partner Boulton made engines for the mines, and for flour mills, and founded the Soho works near Birmingham, which, remodelled, still remain in existence.



3. DIAGRAM OF WATT'S STEAM ENGINE

The Oldest Steam Engine in the World. This [4] is one of the first two constructed by James Watt, in 1776. It remained in regular service from that period till 1898, a period of 122 years. It was built to the order of the Birmingham Canal Navigations, and was removed in 1898 and re-erected at the Ocker Hill Pumping Station, to be preserved as a priceless relic of early engineering. The cylinder of this engine is 32 in. diameter, and the piston has a stroke of 8 ft. It has the old arch head, and chains at each end of a wooden beam, and antedates Watt's famous invention of the sun and planet motion, the parallel motion, and the governor. This venerable relic must have been familiar not only to Watt and his partner Boulton, but to his great contemporaries, Rennie, Telford, Smeaton, and Murdoch. An interesting incident is, that when this engine was superannuated in 1898, the Birmingham Canal Navigations gave the order for the new engine to take its place to the firm James Watt & Co., of Soho, the successors to the original firm, who began business in 1774. These new engines, erected at the Walsall pumping station are up-to-date in all respects, are of vertical type, triple expansion, of 240-horse power, and have a pumping capacity of 12,713,000 gallons per day. Over 500 pumping stations have been supplied with engines from Soho.


4. THE OLDEST STEAM ENGINE IN THE WORLD

Watt Engines and Modern Engines. The engine as James Watt left it, though deemed a giant at that period, was nevertheless an overgrown, heavy weakling, clumsy in its movements, and terribly wasteful in its steam consumption. Comparing the engines of to-day with the best of a hundred years ago, we find that from six to eight times the quantity of coal which is burnt now would have to be burnt if the old engines had survived. The annual coal bill for large mill engines, railway locomotives, and marine engines now runs into enormous figures. If these sums had to be multiplied by from six to eight times, the cost would be prohibitive, and the economic reactions on society would be difficult to forecast.

Readers will be able to appreciate the following comparisons between the old engines and those which embody the best designs to-day. The patriarchal engines often broke down, required constant attendance, and though so massive, they suffered from constitutional weakness; they were asthmatic, wheezy, uncertain in action, huge giants who, consuming vast quantities of coal and water, gave little in return. In May, 1775, Mr. Boulton wrote to James Watt about a new engine which the firm were building: "The engine goes marvellously bad. It made eight strokes per minute, but upon Joseph's endeavouring to mend it, it stood still. Nor do I at present see sufficient cause for its dulness." In 1782, Watt, writing of a Cornish engine by Hornblower, said: "When they have got a very strong steam it will make twenty-one strokes in three minutes, but then comes to rest, and must stand five minutes before it gets strength enough to make another stroke, and all the while they must fire away as hard as ever they can, otherwise it will not work at all."

Now there are many engines to-day of which it is literally true that they might be started and left to run for a year without being touched by the attendant. The engines of a liner continue working during the whole of the voyage from port to port. Engines for electric lighting continue in motion for

many months in succession. The fact that a locomotive makes a run of from 100 miles to 200 miles without a stoppage is considered marvellous. But that, though rather remarkable, is fairly eclipsed by some colliery engines, and engines employed in electro-deposition, which are stopped only once a year, while blast engines run for even longer periods.

Engine Power. Vast power is exerted by the modern engines. A horse power is equivalent to the lifting of 33,000 lb. 1 ft. high per minute, or 1,980,000 lb. lifted 1 ft. high per hour. A 50-horse power engine was a giant a century ago. At the present time the myriads of spindles in the large cotton mills are driven by engines the power of which ranges from 1,000-horse power to 3,000-horse power, or even 4,000-horse power. One particular set of engines of 3,000-horse power in a mill in Bombay weighs 520 tons, the big rope driving-wheel, 124 tons. Eight boilers, 7 ft. 6 in. in diameter and 28 ft. long, are kept constantly going to supply steam to these gargantuan engines, at a pressure of 180 lb. per square inch. They consume 24 tons of coal in the day's work. Yet 1¼ lb. of coal yield a horse power for an hour. If these engines were so wasteful as those at the beginning of the century they would consume about 160 tons in the day's work. The engines of a liner such as the Campania do the work of 30,000 horses. A locomotive engine is a mite beside these, for its strength is only equal to 800 or 1,000 horses. The firm of James Watt & Co., of Soho, were naturally the principal makers of marine engines during the earlier period of their development. Though up to 1854 the firm had manufactured in all 319 marine engines of an aggregate 17,438 nominal horse power, or 52,314 actual horse power, yet in the 79 years thus covered the total horse power was not equal to that of the combined engines of the Campania and Lucania, or of the engines of one of the new Cunarders, the Lusitania or the Mauritania.

Moreover, at the end of the eighteenth century it was impossible to bore a cylinder true. No machine was in existence which would plane or shape or slot metal. There was no true master screw in existence. The elements of the self-acting lathe had only just been put on a practical basis by Maudslay. There was no method of measurement which was precise and reliable.

The Boilers. But these truly magnificent engines are, after all, only means for the utilisation of heat. Behind these are the essential boilers in which the necessary heat is generated in the form of gaseous steam. The history of the growth of the steam boiler is fully as interesting as that of the engines, though to the general reader it is a sealed book. Here are some leading facts. In the time of Watt the pressure of steam did not exceed from 4 lb. to 6 lb. on the square inch, and there were no tubes for increasing the efficiency or heating surface. To-day, pressures of 60 lb. and 80 lb. are low. Locomotives are worked to 150 lb. and 160 lb., marine boilers to 180 lb. and 190 lb., while the water-tube boilers are worked easily to 250 lb. The early boilers were of cast iron, sheet iron, and even of wood. There are few boilers now which are not made of steel.

At that time, Great Britain had accomplished little in the manufacture of wrought or bar iron. The fact now seems scarcely credible that during the period in which Watt had been improving the steam engine, and Hargreaves, Arkwright, Crompton, and Cartwright inventing their wonderful machines, the country should have been dependent upon America, Russia, and Sweden for bar iron. Not till 1784 had Henry Cort perfected the system of puddling and rolling for the production of malleable iron. Though high pressures were necessary fully to develop the power of the new motor, boilers could not be made to endure them. When the eighteenth century closed there were no Cornish or Lancashire boilers in existence, no multitubular marine, or "Scotch" boilers, no multitubular boilers of any kind working commercially, no boilers of steel, very few of wrought iron. The horizontal boiler of the egg-ended type was beginning to be built about 1800, previous to which the waggon boilers had been used. Those were the days of cast-iron boilers, and very low pressures. Power was secured by using large cylinders. Mechanical stoking, though patented, was as yet impracticable

Without the multitubular boiler, neither the locomotive nor the ocean steamships could have been possible. Yet in spite of increased pressures, which, like high speeds, long alarmed timid people, the boiler to-day is vastly safer than the weakling of the early half of the last century. The records of our well-cared-for locomotives and steamships show that the highest pressures are absolutely safe. In fact, an explosion now can never be due to accident or to any mysterious cause. It is wholly preventable, and when it happens is due to neglect, and this is the proper view which the Commissioner to the Board of Trade enforces by fines.

Later Developments. Meanwhile, a race of engineers had arisen, contemporaries and successors of Watt, whose work has left permanent results. The idea of using two cylinders, high and low pressures, for the expansion of steam was advocated by Hornblower in 1781. Later, Woolf, and then McNaught, adopted the same principle, whence the modern compound engine has developed. The principle is commonly applied to land and marine engines, and now rather extensively to locomotives. Its highest development is in the marine engine. But not until 1869 did compound (two-cylinder) engines begin to displace single cylinder engines on the ocean liners of the Atlantic, nor triple expansion engines till 1884.

The modifications made in the steam engine to qualify it for special services will be illustrated in this course. They include the factory, and the high speed central station types; the marine and locomotive, and the rotary engines, including the steam turbines. There are also the internal combustion engines, using gas of various kinds, and oil, in which great developments have been made during the last half-dozen years. Afterwards the generators, the boilers will be considered.

Continued

DRAWING FOR ARCHITECTS

Scales and their Delineation. Drawing Boards. T-squares and Set-squares. The Use of Indian Ink. Colouring and Hatching

continued from page 5352

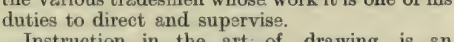
By Professor R. ELSEY SMITH

DRAWING is the chief medium through which the architect expresses his intentions, not only to his clients but to the contractors, and to the various tradesmen whose work it is one of his duties to direct and supervise.

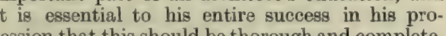
Instruction in the art of drawing is an important part of an architect's education, and it is essential to his entire success in his profession that this should be thorough and complete. In the early stages of this instruction the student must acquire a knowledge of the construction and use of scales, and a mastery over the instruments which are necessary to enable him to make drawings accurately to scale.

Scales. The student is recommended to read carefully the introductory remarks upon Engineering Drawing on pages 2788-9, with reference to scales and instruments. For certain purposes, architects use a scale of $\frac{1}{16}$ in. = 1 ft., or $\frac{1}{192}$ full size; the other scales in ordinary use are $\frac{1}{8}$ in., $\frac{1}{4}$ in., $\frac{1}{2}$ in., 1 in., $1\frac{1}{2}$ in., or 3 in. = 1 ft. Occasionally other scales are used, such as $\frac{1}{12}$ in. or $\frac{3}{8}$ in. = 1 ft., but they are less convenient.

For laying down block plans of sites for submitting to local authorities, a scale of $\frac{1}{22}$ in. = 1 ft. is often required, which is equivalent to



1. SCALE OF FEET



2. SCALE OF FEET AND INCHES

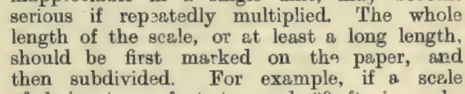
3 in. = 1 chain; and for laying down plans of large estates $\frac{1}{33}$ in. and $\frac{1}{66}$ in. = 1 ft. are also used.

Architects use both open divided scales and fully divided scales; the latter are particularly serviceable in the case of scales of $\frac{1}{2}$ in. = 1 ft. and upwards. It is of the utmost importance that a scale should be divided with the greatest accuracy, as any irregularity will be reproduced in every drawing made with it. The scale is usually divided on both edges, and the same scale may be indicated on both, or two separate scales may be shown, such as $\frac{1}{8}$ in. and $\frac{1}{2}$ in. = 1 foot.

Delineating Scales. It is very desirable that every drawing, except those drawn full size, should have the scale to which they are made drawn upon them, and not merely described in words. This enables any dimension to be read off, with the help of a pair of dividers. In contructing such a scale on paper, the boxwood or ivory scale may be used for marking off on this paper the main divisions, but subdivisions should be redivided with a pair of spring bows to ensure accuracy. Such a scale is usually arranged as an open divided scale. A scale that is intended for reading long dimensions in feet should be divided so that the point 0 lies between the part of the scale divided into multiples of a foot and the part divided into multiples of 10 ft [1]; but it is sometimes drawn with the 0 at the extreme left hand of the scale, and the first 10 ft. only subdivided; this leads to confusion in reading off dimensions, but would be correct if the scale were fully divided. In the same way, where a scale is required for reading feet and inches, the 0 should be placed between the part of the scale divided into inches and the part divided into feet [2].

How to Make an Accurate Scale. Where dividers are used for setting out a scale on paper, it is not sufficiently accurate to set the dividers so as to correspond with a single division on the standard scale, and set out the scale from this unit; for if there is any error in taking off the dimension, this, which may be inappreciable in a single unit, may become serious if repeatedly multiplied. The whole length of the scale, or at least a long length, should be first marked on the paper, and then subdivided. For example, if a scale of $\frac{1}{8}$ in. to a foot to read 60 ft. is to be drawn, the length required for 50 ft., which is $6\frac{1}{4}$ in., is accurately marked by means of a scale or rule, and is subdivided into 5 equal parts, and marked from 0 to 50; an additional length equal to 1 part, which is 10 ft., is marked off to the left of the 0, and subdivided into 10 parts, or feet. Even with the greatest care there may be a very trifling error between the exact length of successive feet, owing to irregularities on the paper and the thickness of the dividing lines; but such an error, if it exists, will not materially affect the accuracy of a long dimension.

The Scale with Minute Divisions. Where the parts into which a scale is to be divided are so minute as to make it impracticable to indicate them side by side in a single line, a scale may be made by using several addi-



3. METHOD OF DIVIDING A SCALE MINUTELY

tional parallel lines exactly equidistant [3]. The number employed must be selected so that it will exactly divide into the number of subdivisions required; the quotient resulting from this division gives the number of parts into which the top and bottom lines are divided. Diagonal lines are drawn from one division in the top line to the next division in the bottom line intersecting the intermediate ones.

As an example: If a line $\frac{3}{4}$ in. in length is required to be divided into 30 subdivisions,

there would be more than can be conveniently shown on a single line [8]. If five additional lines be drawn $\frac{30}{5} = 6$, and the top and bottom lines are subdivided into six equal parts, and the diagonals drawn, the first diagonal cuts the line a at a distance equal to 1 part from the end of the scale, the line b at a distance equal to 2 parts, c at 3 parts, d at 4 parts, e at 5 parts, so that any of these may be read off. In the same way, by using the correct line, any number of parts between 5 and 10, 10 and 15, and so on, may be scaled off.

Beyond the preparation of drawings of a geometrical character to scale, the accomplished architect must acquire facility in freehand drawing from the round, including some knowledge of drawing from the human figure, and must also be acquainted with perspective drawing. These subjects have been already dealt with in previous articles.

Drawing-boards. For much architectural work drawings may be made on paper of imperial size and an imperial board is largely used, and is more handy than the double-elephant size. Occasionally, for large plans, the size known as antiquarian, 53 in. by 31 in., is necessary, but it is unwieldy. The best boards are of pine, with mahogany battens at the back, secured by screws in slots, to prevent warping. One edge is provided with an ebony strip, against which the T-square works.

T-squares are used to draw parallel horizontal lines across a board. They have a thick cross-piece forming the head, one side of which works against the edge of the drawing-board. In the best squares this edge is also formed of ebony. The blade is secured to the head by screws and ebony dowels, so as to be at right angles to it, and is long enough to extend the full width of the board. This also in the best T-squares, which are made of mahogany, has the working edge of ebony, but the cheaper form of T-squares are usually made wholly of pear-wood.

Set-squares. Set-squares are triangles of which one angle is a right angle, and they are used for drawing parallel vertical lines; the lower edge works upon the edge of the T-square, which is held firmly in position against the edge of the board. The upright edge of the set-square will always be truly vertical. The third side is inclined at an angle with the other two. The square is usually made so that the angles between the inclined and vertical sides are each 45°, or are 60° and 30° respectively. Sometimes squares are made to give angles of 50° and 40°, and a square having angles of 63½° and 26½° is also serviceable. The latter is the angle of a quarter-pitch roof, and the former is the angle of the *diagonal line*, by which the height of the back portions of a building are regulated by the London Building Act, and the vertical side of such a square equals twice the length of its base. By shifting the position of the T-square, lines may be drawn parallel to each other with the assistance of a set-square, no matter what angle they make with the horizontal. Set-squares are made of thin, triangular pieces of pear-wood, vulcanite, or celluloid, with a hole perforated near their centre by which they may be hung up. They are also made in mahogany, not solid, but framed of three strips, the centre being open; the edges of these are bevelled, and formed of ebony.

Drawing Paper. Drawing paper may be obtained of various sizes, thickness, and quality for various purposes. Cartridge paper of a buff colour and rather absorbent is used for details and preliminary and rough sketches, but cannot be relied on to take colour well nor to stand much hard wear. A thin, tough detail paper may be used in the same way. For drawings to be finished in pen and ink and colour and for all drawings in which much work is required, a better class of paper is required. For pen and ink work, Whatman's "hot-pressed" and Joynson's "smooth" are suitable, and for colour work, Whatman's "not hot-pressed" and Joynson's "cold pressed." These papers are supplied in sheets imperial size 30 in. by 22 in.; double elephant, 40 in. by 27 in.; antiquarian, 53 in. by 31 in.; and in continuous rolls of 50 yd. long, 30 in., 40 in., 54 in., or 60 in. wide. Numerous other drawing papers are on the market.

Tracing Paper and Tracing Cloth. Tracing paper may also be obtained in standard-sized sheets or in continuous rolls. Such paper, if it is to be used for working out pencil drawings, or if it is to be subjected to hard wear in a building or in a workshop, must be tough; it must also be transparent, so as to allow of any drawing over which it is placed being readily discerned for tracing. This is also necessary if it is to be used as a negative for reproducing by a sun-copying process.

Tracing cloth is made from fine linen rendered transparent, and is tougher and more reliable than tracing paper, but, on the other hand, is less transparent, and if coloured is liable to shrink unevenly. It has usually one side highly glazed, the other side dull. The latter is usually used for drawing upon, the former for colour. This cloth does not take either ink or colour very readily, and should be rubbed over with a little powdered chalk before drawing, which makes the ink take better; the drawing should be tightly pinned to the board when colour is applied. A little ox-gall may be mixed with the colours.

Pencils and Indian Ink. Lead pencils are used in making all drawings. They vary much in intensity of blackness, the range from very hard to soft being H.H.H., H.H., H, F., H.B., B., B.B., B.B.B., but pencils marked with the same letters differ somewhat with different makers. Drawings to ½-in. scale and upwards are often finished in pencil, but drawings to a smaller scale are finished in Indian ink. This may be obtained in sticks, and is then rubbed up in a palette with a little water as required until quite black, or it may be obtained in a liquid form in bottles ready for use. It is important that the ink used should be quite black and opaque, especially if the drawing or tracing is to be reproduced so as to secure a good print. It is also important to secure an ink that, when once dried, will not wash up when colour is spread over it.

It is the general custom among architects to use a rather thick, bold line, but the scale of the drawing must to some extent regulate this. Lines must be well drawn, of even thickness, and carried well up to all angles, and in some styles of drawing they are run a little beyond the angles.

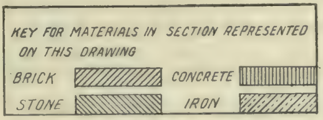
Lines are sometimes formed by a series of dots, where the work indicated by the line is not in such a position that it would really show upon the drawing, but it is nevertheless desirable to represent it. Lines indicating dimensions may be shown by very fine or by dotted lines, or with red or blue ink, and drains are also often represented in *red* ink for soil drains, and *blue* ink for rainwater drains. Brown ink is occasionally used for making drawings in place of black ink.

Colouring Drawings. Most geometrical drawings are coloured conventionally—*i.e.*, no attempt is made in colouring to represent the real appearance of the building, but the colours are used according to a definite scheme in which certain colours represent certain materials; but drawings in elevation, especially if they are to be shown to the client, are often coloured to correspond as nearly as may be to the colouring of the materials employed.

The following schedule gives a list of several of the more important materials used in building, and the colours generally employed to represent them in elevation and in plan or section; but while the colouring is conventional, there is still room for the exercise of a good deal of taste in selecting the exact tints which are to be applied to any set of drawings.

Material	Shown in elevation by	Shown in section by
Brickwork built in mortar	Light red, or Venetian red, or crimson lake, light wash	Same colours used darker
Brickwork built in cement	As above	Purple
Stone	Yellow ochre, pale or left white	Indigo
Wood (unwrought)	Indian yellow, pale	Burnt sienna
Wood (wrought)	Sepia or Vandyke brown	The same colours, darker
Plaster	Yellow or green, pale	Blue-grey
Cement floors	Grey	The same colour, darker
Ironwork	Prussian blue, light	The same colour. dark
Concrete	Payne's grey, light	The same colour, dark
Leadwork or zincwork	Bluish green	The same, darker
Copper	Green	Orange
Slates	Greenish grey	The same colour, dark
Tiles	Purplish red	The same colour, dark
Glass in windows	Grey or lampblack, light	In details Hooker's green

Hatching on Black and White Drawings. Drawings that are to be reproduced in black and white, such as those illustrating this article, cannot be coloured, and where the main walls are uniformly of one material they may be blacked in solidly, or where two or more materials are used, these may be indicated by the use of *hatching*—that is to say, a series of parallel strokes close together, either uniform in quality but differing in direction, or varied in quality. Examples of these are shown in **4**, and their use will be further illustrated in the succeeding article dealing with details. No variation can be made in elevation work to indicate the materials used except so far as this can be indicated by joint lines, and therefore notes as to materials must be more copious. This method is rarely used for ordinary working drawings. Each drawing should have a key to explain the system used, as shown in **4**.



4. METHODS OF HATCHING

Drawings must be cleaned before colouring, and unless the ink is quite fast, should be washed over with clean water and dried off with clean blotting paper. Large washes should be laid on with a large brush full of colour, care being taken to see that an ample amount of colour is ready to complete the wash. Where two colours are combined to form a tint the mixed colour should be constantly stirred to prevent them from separating. If erasures have been made in the drawing, the colour will be soaked up and a dark patch formed; this may be prevented by using a piece of clean blotting paper, with which the spot is lightly touched and the excess of colour taken up.

Preliminary Sketches. In preparing a set of drawings for a building, especially if it is of a considerable size, it is usual to make the earliest sketches to a small scale, say $\frac{1}{16}$ in. to 1 ft. This enables the general disposition to be worked out with considerable accuracy, and makes the drawings more manageable than if they were drawn at once to a larger scale. A beginning is made with the plans, on which the accommodation required must be arranged and rearranged to secure convenience of access between the various parts, suitable aspects and compliance with the requirements of the client; but from the first the effect of the plan upon the elevation must not be lost sight of, and these and the sections must be prepared before any final settlement of the plan is made. It is very desirable also at an early stage to make at least a rough perspective view of the proposed building, from which the grouping and arrangement of the masses may be judged. Where such sketch plans are prepared on paper, it is often desirable to keep a record on tracing paper of any arrangement of a plan or elevation that seems to give satisfactory results, even though it may seem desirable to seek for an alternative one. It is useful for comparison and may contain some point which may be embodied in another scheme, or it may in some cases prove, after all, to be the best solution.

The preliminary drawings may be carefully finished in pencil or ink, and coloured and submitted to the client for consideration, and, when approved, possibly after being modified, they form the groundwork for the general drawings.

Continued

MEDICINE AS A PROFESSION

The Medical Profession as a Career. Its Branches. Examinations and Study. Private Practice. Army and Navy Services. The Specialist

THE MEDICAL PROFESSION

IT is undoubtedly a mistake for a boy to be forced into the medical profession against his will. The preparatory study is arduous, the duties are exacting, and, to those not interested in it, the work may be repulsive. On the other hand, the blending of human with scientific interests makes it fascinating to many. But, as the "Lancet" says, "if only lads who feel an overwhelming call to heal the sick be regarded as fit and proper aspirants to the practice of medicine then we should at once have our schools deprived of hundreds of young men of the best sort." With many such, though the preliminary steps may seem tedious, interest awakens with increasing knowledge, for "as the mysteries of medicine become clearer their labours will become more absorbing."

The chief requirements are great industry, good average ability, good health, the gift of getting on with people, and moderate capital; and of these, perhaps, the greatest is industry. Brilliant talents will naturally help, but they cannot replace systematic study; the steady student makes the "safe" doctor.

The Medical Student. To become a student of medicine it is necessary to pass a preliminary examination [see Schedule].

Before entering for this the student should decide if he intends to try for a University degree, because in that case he must select the examination held by the University at which he wishes ultimately to graduate. If he means to be satisfied with the diplomas M.R.C.S., L.R.C.P. (Member of the Royal College of Surgeons of England and Licentiate of the Royal College of Physicians, London), he will find the one held by the College of Preceptors the simplest of these examinations. The Licentiate of the Society of Apothecaries (L.S.A.) is an easier diploma to obtain, but its status is not nearly so good.

The Schedule of Examinations at the Universities of Oxford and Cambridge is similar to the one given on the next page, but the degree of M.D. is given for a thesis and not by examination. The fees are rather higher.

The student should enter a medical school attached to a hospital. It is outside the scope of this course to recommend individual schools. Such is the loyalty of a medical man to his old school that he will almost invariably be found to recommend his own if his opinion be sought. The chief points to look at are the facilities offered for the practical study of disease, the character of the teaching provided, and the general reputation of the school. We shall speak here chiefly of the schools in London; but with minor differences the facts will apply to the Scotch, Irish, and provincial schools.

Entering the School. In order to enter a school the intending student should call on the Dean or Warden, bringing with him a certificate showing him to have passed the preliminary examination and a certificate of birth. He then pays the entrance fee and signs the register of students, promising to conform to the rules and regulations of the hospital and medical school. He receives a certificate of having begun medical study. The best time for doing this is at the beginning of a session—in April or October.

The candidate should register himself as a medical student at the offices of the General Medical Council, 299, Oxford Street, W. Strictly speaking, this is not necessary, but it is so simple and convenient a way of proving his status that it should be done. The student has only to send the certificate given him by the Dean and he receives a copy of the entry in the register, which he should keep. There is no fee for this.

The minimum time of study required is five years, but it must be remembered that this does not take into account any loss of time from failure to pass any part of the examinations, or for the extra time required for the higher degrees. The student may be surprised to find that for the first two years he is not taught any medicine or surgery, but only the sciences introductory to them. The course of study is divided into three main periods, each ending with an examination. We will suppose, in the first instance, that he is preparing for the diplomas M.R.C.S., L.R.C.P., and afterwards describe the additional courses required by more ambitious students. The first time each subject is mentioned the title of the most suitable book for its study will be given in brackets. The time will be spent in this way:

The Course of Study. The first year will be devoted to preliminary scientific subjects—chemistry, physics, and biology. Supposing the student to enter, as is most usual, in October, he will have to attend lectures and practical work in chemistry (Luff's "Chemistry." Cassell. 7s. 6d.) and lectures on physics (Corbin and Stewart's "Handbook of Physics and Chemistry." Churchill. 6s. 6d.). Some previous knowledge of chemistry, such as is given in many schools to-day, will be a considerable help and will enable the student to employ more of his time in the more medical subjects. He will also attend lectures and practical work in biology (Mitchell's "Outlines of Biology." Methuen. 6s.). He will begin the study of anatomy by learning the bones of the body, and then pass on to dissection (Cunningham's "Practical Anatomy." 2 vols. Pentland. 23s.). For this he will require a set of dissecting instruments costing about £1; and it will be well if he can buy a set of bones for himself at a cost of from 2½ to 3 guineas. At the end of the winter session, in March, he should pass his examination in biology. During the summer session he will continue to work at chemistry and begin the study of physiology by learning the minute structure of the tissues of the body—*i.e.*, histology (Schäfer's "Essentials of Histology." Longmans. 9s. net.). For this purpose he will need to buy a microscope if he has not already purchased one for his biological work. We recommend Leitz's six-guinea microscope; but in any case it should be one that is capable of having more elaborate lenses added to it later for bacteriological work. To buy a cheap instrument which can never be adapted for advanced work is very false economy. In July the student

should be ready to pass his examination in physics and chemistry.

The second year is devoted to intermediate subjects—anatomy, physiology, and pharmacy.

Though the study of anatomy and physiology begins during the first year, it is the second winter session which must be most seriously devoted to these important subjects, which are the very foundations of medical science. Usually there are four lectures in anatomy and three in physiology to be attended each week. Six hours a week will have to be spent in the physiological laboratory, and the remainder of the time (at least 18 hours) must be devoted to dissection.

For this purpose the body is divided into five parts, each student being allotted a part in turn. A charge of 15s. is usually made for each. Meanwhile he is learning from physiology (Starling's "Elements of Human Physiology." Churchill. 12s. 6d.) the way in which the healthy body does its work. He will then be able to appreciate those departures from healthy action which constitute disease.

In the summer of the second year anatomy and physiology should be revised and the study of drugs begun (Hale White's "Materia Medica." Churchill. 7s. 6d. Calvert's "Practical Pharmacy and Prescribing." Lewis. 4s. 6d.). The energetic student may have found time to begin this during his first summer. In July he should pass his examination in anatomy and physiology, and also in pharmacy.

The third, fourth and fifth years are devoted to the final subjects—medicine, surgery, and midwifery.

Study of Disease. Now, the practical study of disease begins. While attending lectures

SCHEDULE OF EXAMINATIONS FOR THE MEDICAL PROFESSION

Time and Place of Examination. Examining Body. Diplomas and Degrees.	SUBJECTS OF EXAMINATION. Subjects that are distinguished under different letters may be passed separately.	Fees and Age Limits for Examinations.
For M.R.C.S., L.R.C.P. Entrance. COLLEGE OF PRECEPTORS.	English. Including Grammar and Composition. Latin. Including Grammar, translation from Latin into English, and from English into Latin. Mathematics, comprising Arithmetic, Algebra, up to easy Quadratic Equations. Geometry—the first three books of Euclid, with easy deductions. Greek, or a modern language. (The following examination certificates are accepted in lieu of this examination : University of London : Matriculation. University of Oxford : Responsions, Moderations, or local examinations. University of Cambridge : Previous or Local Examinations.)	£1 5s.
COLLEGES OF PHYSICIANS AND SURGEONS. Jan., April, July, Oct., First examination.	(a) Chemistry and Physics. (b) Biology.	£10 10s. For re-examination, £3 3s. for (a) ; £2 2s. for (b).
Second examination.	(a) Anatomy and Physiology. (b) Pharmacy and Materia Medica.	£10 10s. For re-examiation, £6 6s.
Third examination.	(a) Midwifery. (b) Surgery. (c) Medicine, Forensic Medicine, and Public Health.	£21. For re-examination, in (a), £3 3s. ; in (b) or (c) £5 5s.
For F.R.C.S. ROYAL COLLEGE OF SURGEONS. May and November. Primary examination.	Anatomy and Physiology.	£5 5s.
Final examination.	Surgery.	£12 12s. On admission a further fee of £13 13s. (reduced to £3 3s. for those holding M.R.C.S. diploma). 25 years
For M.R.C.P. ROYAL COLLEGE OF PHYSICIANS. Every three months.	Medical Anatomy, Principles and Practice of Medicine, Principles of Public Health, and Psychological Medicine, Translation from Latin, and either French, German, or Greek.	£6 6s. for examination, £35 14s. on admission, reduced to £19 19s. for Licentiates.
For M.B., B.S. UNIVERSITY OF LONDON. 1. Matriculation. Jan., June, Sept.	English, Elementary Mathematics, Latin or Elementary Mechanics, or Elementary Physics, or Elementary Chemistry, or Elementary Botany. Two optional subjects, selected from Languages, History, Logic, Physical and General Geography, Natural Sciences.	£2 16 years
2. Preliminary Scientific. Jan. and July.	(a) Inorganic Chemistry and Physics. (b) Biology. (c) Organic Chemistry.	£5
3. Intermediate. Jan. and July.	(a) Anatomy and Physiology. (b) Pharmacology.	£10
4. Final. Oct. and May.	(a) Medicine, General Pathology, Forensic Medicine, and Hygiene. (b) Surgery, Midwifery, and Diseases of Women.	£10 For re-examination, £5. 21 years
M.D. Dec. and July.	One of the following subjects : Medicine, Pathology, Mental Diseases, Midwifery and Diseases of Women, State Medicine.	£20 25 years
M.S. Dec. and July.	Surgery, Surgical Pathology and Anatomy, Operative Surgery.	£20 25 years

on medicine (Osler's "Principles and Practice of Medicine." Appleton. 18s. net; or Taylor's "Manual of the Practice of Medicine." Churchill. 16s.) and surgery (Walsham and Spencer's "Theory and Practice of Surgery." Churchill. 15s.) the student starts as a "dresser." Under the direction of his house surgeon he attends to the multitude of smaller accidents and surgical ailments with which the out-patient room is crowded. Later he attends in the same way to the more serious cases in the surgical wards, and assists in a minor capacity at operations.

During this time he is attached to the service of one of the visiting surgeons, to whom he must make himself useful in every way he can. The student is usually allowed to select the "chief" under whom he will serve. A good chief teaches both by example and precept, is regular and systematic in his hospital work, and expects system and regularity in his dressers. The mental stimulus of a group of keen and inquiring students reacts on him, too, keeping him alert and progressive in his methods. To select an easy-going chief may be pleasant to the lazy student, but it is a fatal mistake.

Six months to a year should be spent as a dresser, but not consecutively and not necessarily under the same chief. After the first three or six months of dressing, the student passes over to the medical wards, where he acts as a "clinical clerk" for one of the visiting physicians. Here he occupies a similar relationship to his chief as in the surgical wards. Each physician or surgeon appoints a recently qualified student his resident house physician or house surgeon, who is in charge of the cases between the visits of the chief. It is the ambition of every keen dresser and clerk so to perform his duties as to obtain this position later on.

Midwifery. During his third summer session the student will begin the study of midwifery (Galabin's "Midwifery." Churchill. 15s.) at lectures. When he has completed these, together with one term of dressing and clerking, he attends confinements. Most hospitals have a district where poor women are attended in their own homes. It is an excellent system for both sides—the student has his first real taste of responsibility and the patient gains the services of one well grounded in his duties, who is acting under the supervision of a resident medical officer, for whom he is bound to send in case of any complication. At least 20 cases must be attended by every student, and though this may be done more pleasantly, perhaps, at a lying-in hospital, the student escapes responsibility thereby and loses an insight into the lives of the very poor which is invaluable to every medical man.

By this time the fourth year will have been entered. Of this three months should be spent in the department for the diseases of women (Herman's "Diseases of Women." Cassell. 25s.; Herman's "Difficult Labour." Cassell. 12s. 6d.). A course of tutorial classes is also held, and after that the midwifery part of the Final Examination should be passed.

Concurrently with all this the student will have his energies taxed by attendance at lectures on important branches, like forensic medicine, dealing with medico-legal questions (Husband's "Forensic Medicine." Simpkin. 10s. 6d.); public health (Whitelegge's "Hygiene." Cassell. 7s. 6d.); and pathology (Green's "Pathology." Renshaw. 17s.; Bowlby's "Surgical Pathology." Churchill. 10s. 6d.). Every year the importance of pathology—the study of the processes of disease and their effects on the bodily tissues—increases. The student must lose no opportunity of practical work in this department. He must assist in post-mortem examinations, he must study diseased tissues both in the museum and with the microscope; he must learn to examine the blood and the commoner microbes. No one who neglects pathology can aspire to be up-to-date as a medical man.

Special Studies. The diseases of the eye (Swanzy's "Ophthalmic Surgery." Lewis. 12s. 6d.), the skin (Malcolm Morris's "Diseases of the Skin." Cassell. 10s. 6d.), the throat and ear, and orthopædic surgery will occupy the time until the fifth year has been fairly entered. A fever hospital must be entered for two months (fee, three guineas; for the higher examinations three months' attendance is required—fee four guineas).

The student must also acquire some knowledge of insanity (Savage's "Insanity." Cassell. 9s.) by lectures and by seeing cases at an asylum. He must also take a course of operative surgery (Treves' "Student's Handbook of Surgical Operations." Cassell. 7s. 6d.; Treves' and Keith's "Surgical Anatomy." Cassell. 9s.). The fee for the elementary class is usually one guinea; for the advanced class (for higher examinations) five to seven guineas. A certificate of proficiency in vaccination must be obtained by attendance at a vaccinating station (fee, one guinea). The student should also learn to administer anæsthetics. Such time as remains will be occupied in obtaining experience in the wards and out-patient rooms of the hospital. What he *sees* will be remembered better than what he *reads*. The best method is to read up at night the diseases of which he has seen examples during the day. Revision classes are also held before every examination to refresh the memory. The student should now be in a position to pass the rest of the final examination (medicine and surgery, taken separately or together) and receive his reward by emerging as a fully-qualified medical man.

As soon as he obtains his first qualification, the *medical man* must register himself at the offices of the General Medical Council, no matter whether he previously reported himself as a student or not. The fee is £5. This is essential, as the Medical Register is the official list of the members of the profession. Subsequent qualifications can be registered for a fee of five shillings.

The Higher Examinations. The possession of a University degree is a great help to a medical man. The degrees of the London University necessitate a more prolonged course of study than that described above. The whole of the first year must be spent on the preliminary scientific subjects. Advanced classes in physiology and anatomy must be attended, and a course in organic chemistry is needed. Two years' study will be required for the intermediate examination. The final examination is decidedly harder. The degrees of Doctor of Medicine or Master in Surgery will require about two years' study after taking the degrees M.B., B.S. Students who intend to take degrees at Oxford or Cambridge reside during their first three years at the University and should pass their examination in anatomy and physiology there. They enter a London hospital for the final subjects only, and a proportionally reduced fee is charged. The final examination for the degrees of Bachelor of Medicine and Bachelor of Surgery resembles in essentials that required by the London University. The degree of M.D. is obtained by writing a thesis and not by examination.

The Fellowship of the Royal College of Surgeons (F.R.C.S.) is essential to anyone taking up surgery as

a speciality, and is an excellent diploma for anyone to possess in general practice. The subjects of the primary examination are anatomy and physiology; of the final, surgery. Special classes must be attended for these examinations, which are decidedly difficult and notoriously uncertain.

The Membership of the Royal College of Physicians (M.R.C.P.) is essential to anyone intending to practise as a consulting physician, but it is a drawback to general practice. The holder may not buy or sell a practice, may not enter into partnership nor dispense medicines. He is expected not to charge a lower fee than one guinea.

Expenses Incurred. The London hospital fees given in the table below do not include fees for courses in fevers, operative surgery, and vaccination [see above]. Fees in the Scottish, Irish, and provincial schools are somewhat lower.

Beyond expenses incurred for fees, at least £10 a year should be allowed for books and instruments. Backward students may require private tuition from time to time; the fee for a three months' course is 10 guineas. If the student can live at home a great saving naturally results, but the great majority live in lodgings. Several hospitals have residential colleges attached. For the greater part of the course it is not advisable for the student to live in college, however. Change of air and surroundings is preferable. While working for the final examination a short residence in college is profitable because it enables so much emergency and night work to be seen. Many of the teachers receive students to live with them for an average fee of two guineas a week; this ensures a certain amount of supervision. The "Lancet" says: "If a London student is careful and orderly, if he selects rooms in an inexpensive quarter of the metropolis—not always easy to do if his school is placed in the West End of London—if he requires no private coaching, and, if, by industry and ability, he is able to make certain of his examinations as the time comes for them, he can make an allowance of £100 a year for five years support him during his educational career. But his parents or guardians should remember that if he has no need to have recourse to them it is because he has shown considerable self-control and has resolutely turned his back upon many pleasures, which, however innocent, cost the odd shillings that he has never possessed."

HOSPITAL FEES FOR MEDICAL STUDENTS IN LONDON

Hospital	Fees	Remarks
St. Bartholomew's	£31 10s. entrance fee	
	£31 10s. annual fee	
	or £173 5s.	If paid in one sum
Charing Cross	£132 6s.	If paid in five instalments
	or £120 15s.	If paid in one sum. For the sons of medical men, 115 and 105 guineas respectively
St. George's	£160	In four instalments
	or £150	If paid in one sum
Guy's	£21 entrance fee	—
	£31 10s. annual fee	—
Kings' College	£148	In four instalments
	or £135	If paid in one sum
London	£136 10s.	If paid in three instalments
	or £126	If paid in one sum. A reduction of 15 guineas to sons of medical men.
St. Mary's	£145	If paid in four instalments
	or £140	If paid in one sum
Middlesex	£152 5s.	If paid in four instalments
	or £141 15s.	If paid in one sum
St. Thomas's	£21 entrance fee	—
	£31 10s. annual fee	—
University College	£31 10s.	For first examination
	£52 10s.	For second examination
	£84	For third examination
Westminster	£126	If paid in half yearly payments
	or £115 10s.	If paid in one sum
Royal Free (for women students)	£150	If paid in four instalments
	or £140	If paid in one sum

How to Enter Upon Medical Practice. The newly-qualified man has still much to learn. By far the best way of rapidly acquiring experience is to hold the post of house physician, or house surgeon, for six or twelve months at some hospital. It should be the aim of every student to hold one of these posts, for no finer training exists. It stamps a man in a way which the trained observer can generally detect. Living amid his patients he learns to recognise minute hourly changes in their condition, so that in after life he can draw correct conclusions rapidly and confidently. He is responsible for all treatment between the visits of his chief, to whom he can always turn in case of any difficulty. During the time he holds office board and lodging is supplied, and in some cases a small salary is paid.

But hospital practice differs widely from private practice. In the former, everything is organised and ready for all emergencies, the house surgeon having merely to order what he wants. In private practice considerable ingenuity must be shown in improvising arrangements for the sick room, where the orders are not as a rule carried out by trained assistants. Much more tact and diplomacy are required. Delicate family questions come up constantly which the doctor would never have to face in hospital work. And instead of simply doing charitable work, his profession has now to be conducted so as to yield an income.

Without guidance through this maze he may make mistakes that will mar his professional chances. He must remember that, in general, the public are incapable of judging his professional merits, but they can appreciate his bearing and conduct; and they conclude that the latter is the measure of the former. The old system by which the medical student was the apprentice of a doctor had many grave drawbacks which render it quite unsuitable to-day; but it had one advantage, that he learned many of those practical details which cannot be taught in hospitals. The best way of learning these points to-day is to act for a time as a "locum tenens," or as an assistant.

The Locum Tenens. While deputy for a doctor the "locum tenens" lives in his house, receiving board and lodging and a fee of three or four guineas a week. A living can therefore generally be made in this way; but it must be strictly regarded as a temporary expedient; to continue to do this long is not to be commended. It is more instructive to act as "locum tenens" for one member of a partnership. From the remaining partner he can learn much about the method of conducting the practice, and the idiosyncrasies of the patients. He must not be surprised if this partner selects the best work for himself, leaving the residue and the greater part of the night work to the "locum."

If there is no partner it is usual for the "locum" to arrive before the departure of the doctor whose

work he is going to do, in order to receive instructions. After that he will be dependent on the dispenser, or even the coachman (both generally well-informed and discreet) for his information, though in some cases the doctor's wife will stay behind to look after things. The "locum tenens" is bound in honour to consider in every way the interests of the doctor he represents. He need not be surprised if some patients refuse to see him; the choice of a medical attendant rests with the patient, and no man can do much good to a sufferer who is unwilling to receive him. He must reflect that when he gets a practice of his own he will not care to have his deputy received too gladly.

Setting up in Private Practice. Many men consider it beneath their dignity to act as an assistant. With the suppression of unqualified assistants by the General Medical Council, however, the position and emoluments of the qualified assistant has improved. If he lives with his principal he will receive from £120 to £150 a year.

For a young man there is a good deal to recommend such a position for a time. He sees practice and gains experience without risk of capital; he is taking no irrevocable step. Some assistantships are held "with a view to partnership." This is a convenient arrangement, allowing the principal and assistant to know one another thoroughly before entering into the more enduring bonds of partnership. An assistant is usually bound by agreement not to practise for himself in the district, except in partnership with his principal. This prevents an unscrupulous assistant from getting an introduction to patients and then subsequently diverting them to himself.

Sooner or later, however, the decisive step must be taken. But without capital this is difficult. The cost of a medical education does not exhaust the expenses incurred in entering the profession. The ordinary methods are three: (1) squatting; (2) buying a practice; (3) partnership.

Squatting. Squatting, as it is euphoniously called, means taking a house in a suitable district, putting up a door-plate, and waiting for practice. In no case should this be expected even to cover expenses in less than three years. It will be seen, therefore, that expenditure of capital is really involved in keeping up an unremunerative house. Moreover, there is a considerable element of risk, for after three years the practice may still be most meagre. A town with a fixed population offers no scope for this method, which should only be attempted in a rapidly-growing district. Without influential introductions the chances are that the practice will be drawn from the poorer classes, who are not nearly so conservative in the matter of medical attendants. Moreover, "undesirables" who have exhausted their credit with the more established practitioners regard the new man as their legitimate prey. The young doctor is delighted with his apparently rapid success until the time comes for settling accounts.

The custom is for the new doctor to call upon his medical neighbours and announce his intention of practising. This is rather an ordeal, for, the demand for doctors being the same whatever the supply, the new-comer can hardly expect an enthusiastic welcome, though, of course, he will have a courteous reception.

There is another method which should be condemned. Occasionally, friendly societies and sick clubs advertise for a doctor to settle in a town as their medical officer. The salary is usually just enough to live upon, and a young man may regard this as forming the nucleus to a practice which he can develop. But the club only adopts this course when it has failed to get the doctors in residence to accept their terms. The terms usually accepted cannot be called extravagant—a penny a week for the head of the family, and less from the other members. This scale is found to yield an average of tenpence a visit, from which the cost of medicine supplied must be deducted. The services rendered are therefore in part charitable. But from time to time the larger tradesmen and employers of labour are found in these clubs expecting treatment on the same terms as artisans and labourers. Refusal to act for a club has generally been based upon this ground. If the resident practitioners object, the club will advertise for a medical officer, the aim being to punish them by importing a rival. If a man accepts such an appointment, he is entirely dependent upon the club officials, who will show him scant consideration. At the same time he cannot expect cordial relationship with his professional colleagues.

Buying a Practice. The best class of practice does not often come into the open market, the contracting parties being introduced through their medical school. An influential member of the visiting staff is asked to recommend a suitable man whose capabilities he knows personally. In this way, a student finds a good reputation at his hospital is a valuable asset, while the vendor gets a man whose personal qualities have been appraised in a way a medical agent is unable to do. This method is, perhaps, more usually employed in obtaining a partner than a successor. In whatever way the introduction has been effected, however, the practice should be investigated by a recognised medical agent, who will go through the books and value it. No objection is raised, as a rule, to this; if it is, negotiations should cease. For, without any fraudulent motive whatever, a vendor may take too roseate a view as to the extent to which the practice is transferable. A death vacancy is of notoriously uncertain value, especially if the preceding illness has been prolonged. During this time, a practice crumbles away surprisingly. In any case, many patients will transfer themselves, not to the new doctor, unknown to them, but to one of the other practitioners already established in the district.

Not more than one year's purchase should be paid for a death vacancy, and the successor should not anticipate holding more than two-thirds of the existing practice.

A much safer plan is where the outgoing practitioner is willing to give his successor an introduction by staying on for six months or so. In this case, about one and a half years' purchase is usually asked.

Partnership. From a pecuniary standpoint, this is undoubtedly the safest plan. It would seem to have other obvious advantages, such as a colleague's assistance on all occasions when requisite, and greater freedom in getting away. Yet in medical practice partnerships seem, as a rule, much less successful than in other walks in life. Perhaps this is because of the intimate personal relationship between doctor and patient into which a third person introduces a disturbing element. Moreover, "partners are not usually equally matched in industry, capacity for work, tact, temperament, and other qualities indispensable to an intimate and congenial fellowship, and are not equally cared for by the public" (Cathell). If one partner does most of the work, he chafes at earning money for the other, while the latter feels jealous of the superior

popularity of the former. Whatever the cause, really satisfactory partnerships are unfortunately not common. A higher premium is usually paid for a partnership than for a simple succession, the present price being two to two and a half years' purchase.

The Daily Round. It is usual for the doctor to be at home from 9 to 10 or 10.30 in the morning to see patients; if he has club or parish patients, they should be seen at his surgery then. This gives time for the arrival of messages requesting him to call. The morning round should start not later than 10.30, and should be so arranged as to allow a visit home in the middle of the morning to collect any fresh messages. The necessity for an afternoon round will depend on the size of the practice. The afternoon is usually the time fixed for consultations with other medical men. The doctor should set aside certain hours in the evening for seeing patients at his house. Many patients not confined to their room much prefer this method. The time of the next visit should always be mentioned, and should not be left vague; a little tact will generally discover the wishes of the patient as to frequency of visits, and will avoid the charge either of being neglectful or of undue persistence. It should be made clear that for a special visit—that is, one made out of the morning or afternoon round—a special fee will be charged. In this way much time can be saved, and dislocation of the work avoided. But midwifery will always upset the doctor's calculation. Four-fifths of his night work will be due to this—the greater number of births occurring between midnight and 3 a.m. The fees are much smaller in proportion than for any other professional work. Yet no young man can afford to decline such engagements, as the children become his patients, and thereby practice grows.

The Chances of Success. Sir James Paget found that his first thousand pupils met with the following degrees of success:

Twenty-three had distinguished success—that is, they attained to a leading position in practice or to important public appointments.

Sixty-six had considerable success—that is, they held high positions in the Services, or obtained good provincial or country practices, and enjoyed more than ordinary esteem and influence in society.

Five hundred and seven had fair success—that is, they possessed a practice large enough to maintain them in adequate style, or the tenure of an advancing position in the Services.

One hundred and twenty-four had very limited success—that is, they never attained moderately good practices, but were just able to maintain themselves.

Fifty-six failed. Of these, 15 could not pass their examinations, 10 were dissipated both as students and afterwards, 10 had bad health, and 5 were convicted of misconduct.

Ninety-six discontinued medical studies while still pupils.

Forty-one died during pupilage.

Eighty-seven died within 12 years of beginning practice.

Deducting these last three groups, therefore, 776 actually reached practice, and of these, 596, or rather more than three-quarters, achieved a reasonable degree of success. Later investigations have yielded similar figures. This is an encouraging result; but we must remember that success in practice does not mean the attainment of wealth. We may conclude that to the industrious and well-qualified doctor the medical profession offers a good chance of only an adequate income in return for an arduous but interesting and useful career.

The Doctor's Library. In addition to the books mentioned in the course for the final examination, these will be found very useful:

"A System of Medicine." Clifford Allbutt. Macmillan. 8 vols. £10 net.

"Manual of Medicine." Allchin. Macmillan. 5 vols. £2 net.

"Principles of Treatment." Mitchell Bruce. Pentland. 16s.

"Diseases of the Throat, Nose, and Ear." McBride. Pentland. 25s.

"Diseases of Children." Goodhart & Still. Churchill. 12s. 6d.

"Clinical Methods." Hutchison & Rainy. Cassell. 10s. 6d.

"Food and the Principles of Dietetics." Hutchison. Arnold. 16s. net.

"The Extra Pharmacopœia." Martindale & Westcott. Lewis. 9s. 6d. net.

One of the weekly medical journals should be taken in. Of these, the "Lancet" (7d. weekly) is the best. The "Practitioner" (21s. a year), published monthly, gives excellent reviews of medical progress.

THE DOCTOR ABROAD

One out of every five men qualifying as doctors in Great Britain ultimately comes to practise abroad, usually in the Services or in the Colonies. This does not include the large number who take a temporary post as surgeon on board ship in order to see something of the world before settling down in practice at home. For all these, a course of study at the School of Tropical Medicine in London or Liverpool is essential.

The Doctor in the Navy. Admission to the Naval Medical Service is by examination in medicine, surgery, and allied subjects. Candidates must be between 21 and 28 years of age, of pure European descent, the sons of British parents, of sound constitution and good character, and qualified medical men. Successful candidates receive commissions as surgeons, and study naval hygiene, etc., at Haslar Hospital before proceeding to their station. Pay starts at £225 10s. a year and rises to £657 for Fleet surgeons. Retirement is compulsory at 55, except for Deputy Inspector-generals and the Inspector-general. But voluntary retirement is permitted after four, eight, 12, and 16 years full-pay service, with gratuities of £500, £1,000, £1,500 and £2,250 respectively. Herein lies one of the great attractions of the Service, for a man without capital entering at, say, 22 can withdraw at 30 with £1,000 to start in civil practice. Fleet surgeons retire with a pension of from £365 to £547 10s. a year, according to length of service. But if the health of a surgeon breaks down before he completes 20 years' service, he may be placed at once on the retired list, receiving no pension, but only a gratuity, even if his illness has been contracted in the performance of his duties. This seems decidedly unfair.

A naval surgeon has excellent opportunities for keeping himself in touch with medical progress, as he is obliged to attend a post-graduate course at a metropolitan hospital for five months every eight years. During this time he receives full pay and allowances for expenses.

The Doctor in the Army. The requirements from candidates are similar to those for the Naval Medical Service, except that the subjects of examination are limited to medicine

and surgery. Successful candidates receive commissions as lieutenants on probation, and must undergo two months instruction in military surgery, hygiene, and bacteriology at the Staff College in London. They will be examined in these subjects and then go to Aldershot for a three months' course of instruction in technical duties, on which they are also examined. Examinations for promotion are held later. The daily pay of a lieutenant is 14s. a day, exclusive of allowances, rising with promotion and length of service to £2 a day for a colonel and £3 for a surgeon-general. Retirement is compulsory for a surgeon-general at 60, for a colonel at 57, and for other officers at 55. Failure to qualify for promotion will entail retirement at an earlier age. The rate of retired pay varies from £2 to £1 a day, according to rank. Majors of less than 20 years' service and captains receive gratuities varying from £2,500 to £1,000 in place of retired pay. If premature retirement is the result of illness produced by medical service, the officer receives retired pay equal to the half-pay of his rank. An officer volunteering for, or ordered to, the West Coast of Africa receives double pay. For each year's service here he is entitled to full pay during a year's leave at home. Each year and each half-year after the first twelve months are counted as double for purposes of retired pay.

The conditions of the Army Medical Service have been much improved of late years. The chief drawback is that there is still a tendency in certain quarters to place the medical officers on an inferior plane socially to the combatant officers.

The Indian Medical Service. Regulations for candidates in the Indian Medical Service resemble those for the Army, except that they must simply be "natural born subjects of his Majesty," European descent not being insisted on. An additional certificate is required of having attended a course of instruction in diseases of the eye for not less than three months. The subjects of the examination are now the same as for the Army. Successful candidates undergo further training at the Medical Staff College and at Aldershot as for the Army, and have a similar examination at the end. According to the result of all these examinations, they are allowed, as far as possible, to select their district in India. Leave out of India for a year, capable of extension to two years' absence from duty, is granted at certain times on pay varying from £250 to £700 a year, according to length of service. Extra leave is allowed also for purposes of study.

The system of pay is somewhat complicated, but usually starts at 450 rupees a month, increasing to 2,250 rupees for those below the rank of surgeon-general, who receives 3,000 to 2,200 rupees. Retirement takes place at 55 or 60, according to rank, and the pension ranges from £1,050 to £300 a year, depending on length of service and position. Invalid pensions are also granted to officers incapacitated by illness caused by their duties.

The competition for the Indian Medical Service is more severe than for either of the other two Services. It should be entered as early as possible, since it is almost impossible for anyone entering after his twenty-fifth birthday to reach a higher pension than £500 a year. Private practice is allowed, except to those in certain special posts, as long as it does not interfere with official duties. This allows the chance of a decidedly better income. "Specialist" appointments have recently been made, which carry higher pay with them.

It is now permitted to successful candidates in all three Services to spend not more than a year in a resident appointment at a recognised civil hospital. Time so spent counts towards promotion and pension. This is a great improvement, and encourages the best type of student to compete.

The Doctor in the Colonies. There is, of course, considerable scope for the medical man in the Colonies.

CANADA. British diplomas and degrees entitle a medical man to practise in Canada without any examination after licence obtained from the Provincial Medical Boards and registration and payment of fees. In British Columbia the registration fee "must not exceed $100," and in some parts is only $10; a small annual fee may also be charged. There are good medical schools in Canada, so that the supply of medical men is quite sufficient for the population generally, though British Columbia might offer an opening to those ready to "rough it."

AUSTRALASIA. In New South Wales, Victoria, Queensland, and Tasmania, a man who possesses British qualifications is entitled to a certificate from the Medical Board as a "legally qualified practitioner." In Western Australia a fee of ten guineas, and in New Zealand a fee of £1 5s., is charged for such registration. Registration is not compulsory in South Australia.

In Australia there is a large supply of general practitioners in the towns, and many of those who have gone out from England have found it difficult to make a living. The graduates of the Colonial universities more than meet the usual vacancies, and have more influence to help to secure them. There is, however, still some opening for specialists on diseases of the eye and ear. For others country districts offer the best chance, but the newcomer must be proficient in surgery as well as medicine, and ready to live a hard life.

SOUTH AFRICA. Here registration is necessary. For this sworn declarations must be made as to (1) personal identity, (2) authenticity of the diplomas, and (3) the fact that these diplomas entitle the applicant to practise in the country where they were obtained. Registration by the General Medical Council of Great Britain will be found to simplify these procedures.

In Cape Colony the licence is signed by the Colonial Secretary on the recommendation of the Colonial Medical Council. The fee is £5. In Natal the application for such a licence costs £1 1s., and the annual fee is £5. In Southern Rhodesia the licence is issued by the Chief Secretary, Salisbury. The fee is £5. In the Transvaal the certificate is issued on the recommendation of the Transvaal Medical Council on payment of £10. In the Orange River Colony the Registrar of the Medical and Pharmacy Council, Bloemfontein, issues the certificate. The stamp is £7 10s., and the annual licence costs £15.

In Cape Colony there are numerous appointments as district surgeons and medical officers. Candidates should apply to the Assistant Private Secretary, Colonial Office. Applications for appointments in Rhodesia should be made to the Secretary of the British South Africa Company, London Wall Buildings, E.C., together with certified copies of diplomas and testimonials. Preference is given to applicants who have passed through a course of training at the Tropical School of Medicine. It is desirable that they should be young, of good physique, and able to ride.

Those who go out to South Africa with a view to private practice must remember that though

fees are high, so is the cost of living, and that methods of competition are in vogue which are not sanctioned in Great Britain.

OTHER COLONIES. Medical appointments fall vacant from time to time, mainly in the West Indies and the West African Colonies. Candidates must be between the ages of 23 and 30, must be doubly qualified—*i.e.*, in surgery and medicine—and must apply to the Assistant Private Secretary, Colonial Office.

The Doctor on the Continent. On the Continent, as a rule, fewer opportunities offer themselves to the practitioner.

ITALY. Italy is the only country that places no restriction on the foreign practitioner. He has no fees to pay, examination to pass, or forms to comply with. The authorities recognise the benefit of the large influx of visitors and the necessity of considering their comfort, so that a recent agitation to expel all foreign practitioners has met with little support. The shortness of the season in most districts means, however, three or four months of incessant labour, followed by comparative idleness during the rest of the year, unless it is combined with a practice in some summer resort, entailing the expense of a double establishment. As such practices are of a purely personal and non-transferable nature, they should not be bought. Good general attainments, and especially good introductions, are of more value than a bought connection.

FRANCE. Application must be made to the Minister of Public Instruction, accompanied by sworn translation of the birth certificate and diplomas viséd by the British Consul. Then the degree of M.D. in a French University (involving five examinations) and the "diplome de Bachelier," must be obtained before practice is allowed. Classes must be attended even by the qualified foreigner, though he does not have to wait the statutory intervals between his examinations. When all these difficulties have been surmounted, a man who can accommodate himself to his surroundings may find a good opening in towns where there is an English-speaking element.

GERMANY. All the classes must be attended, and all examinations have to be passed. As this involves a five years' course and about £160 to £170 in fees, it is practically prohibitive. Practice is allowed to holders of British diplomas, but they must not make use of titles resembling those of German medical men, and legally they are regarded as unqualified. Under such circumstances Germany offers no attraction to the British medical man.

AUSTRIA. Naturalisation, involving five years' residence, is necessary, and all the examinations must be passed.

HUNGARY. Application must be made to the Minister of Education, three examinations must be passed, and a fee of 80 crowns paid.

SWITZERLAND. Three examinations must be passed (fee £9), and one or two years spent in additional study.

SPAIN (and Canary Islands). The diploma must be sent to the University of Madrid, and identity proved. Practice is then allowed on the payment of certain duties.

PORTUGAL (including Madeira and Cape de Verde Islands, where there is a considerable British element). Examination and a printed dissertation are required. Cost of examination and diploma, £50.

TURKEY. A "colloquium," or easy oral examination in French or Turkish, without interpreter, is held. No European physician has ever failed to pass this, but there may be many delays before the examination is actually held. Fees, £8, in addition to some registration expenses.

EGYPT. Qualified British practitioners have only to show their diplomas to the Director General of the Sanitary Department in Cairo, obtain a certificate of good character, and pay a small registration fee. Formerly Egypt offered a splendid opening, but so many availed themselves of it that this holds good no longer. No one should go there unless he has obtained an appointment in the Kasr-El-Ainy Hospital or in the Sanitary Department, for which the competition is considerable. A knowledge of Arabic is essential.

JAPAN. There is no difficulty in an English medical man obtaining a licence, which only costs about six shillings, but the only opening is for shipping work and as medical officer to business houses.

UNITED STATES OF AMERICA. The methods of admission vary in the different States, and are not exacting, but the proportion of medical men to the population is higher here than in any other country, so that competition is very severe in all the situations that are in any way desirable.

THE SPECIALIST

In view of the enormous growth of specialism in medicine, an increasing number of the more ambitious students will desire to equip themselves for such work. It cannot be too clearly understood that whatever speciality a student may be aiming at, it will be necessary for him to become fully qualified to practise both medicine and surgery first. In addition, if a surgical speciality is his goal, the F.R.C.S. is essential to him; if medical, he should become an M.D. of the university in which he was trained, and take the M.R.C.P. The F.R.C.P. is only obtained by election from the more distinguished M.R.C.P.'s, the choice being practically vested in the Council of the College of Physicians.

The Position of the Specialist. It must be remembered that specialism is more popular outside than within the profession. The profession recognises a clear distinction between general practitioners and consultants, the latter treating only patients in conjunction with the general practitioner. The consultant may practise surgery or medicine, never both. The rapid growth of knowledge has made it impossible for the consultant to keep in touch with the whole of either subjects, however. Certain departments, such as diseases of the eye and the diseases of women, have long been relegated to specialists. Diseases of the throat and ear, and of the skin, are now almost entirely treated by specialists. Subjects such as electrical treatment and public health have recently been marked off as separate departments; but beyond this the profession rightly discourages excessive specialism as encouraging too narrow a view. A man elects to practise medicine or surgery, but his gradual recognition as a specialist in some department of either subject depends largely on his fellows who may seek his help on some point to which he has paid special attention.

To specialise in public health a diploma, D.P.H., should be obtained in the subject. This necessitates at least a six months' course in the subject at the hospital, after qualification (fee, usually £21), and examination by the universities or the Colleges of Physicians and Surgeons (fee, usually £21). The successful candidate then attempts to be elected Medical Officer of Health for some borough or district council.

The Specialist's Prospects. This is the only speciality requiring a separate examination. As to the others, it is inadvisable for a student to choose too soon in his career. He must see how his abilities, tastes, and opportunities develop. After qualification, he must aim at holding a resident appointment at a hospital devoted to the speciality he desires to follow. A three or six months' course at a continental clinic, such as Vienna, would then be very valuable. On returning he must try and become a clinical assistant at a hospital in his special subject. A teaching appointment at his own hospital is one of the most powerful levers he can obtain towards his upward progress. He must aim at getting a permanent appointment on the visiting staff of a hospital as soon as possible. The degree of success he has had in his teaching work and as clinical assistant will prove important factors in accomplishing this aim.

It will be seen from this that to become a recognised specialist is a tedious procedure, involving years of unremunerative work. Even when success begins to come, the income earned is much smaller than the public imagines. So much time must still be spent in hospital work and research in order to keep abreast of the times. A specialist must remain a student all his life, always ready to learn and apply the latest scientific work. Without capital it is almost impossible to live through the early years of waiting, though quite exceptional men have done so. A young surgeon has a much better chance than a young physician, because he can earn fees by helping a senior at his operations, and by doing operations at reduced fees, the graduation of fees being much more marked in the case of surgeons than physicians. But a physician goes on earning his income later in life.

In any case the harvest-time for so much preparation is but short, competent authorities putting it at only fifteen years.

It will be seen that the pursuit of specialism is arduous and hazardous. There are as many blanks as prizes to be drawn, and no one should take it up as a career without carefully counting the cost.

HOMŒOPATHY

By Dr. John H. Clarke

Homœopathy is a science and art of healing founded on a law of Nature known to exist from time immemorial, but first clearly enunciated and systematised by Dr. Samuel Hahnemann about the close of the eighteenth century.

Hahnemann was the leading authority on pharmaceutics of his day, being the author of the classic "Apothekerlexicon." He was, therefore, fully acquainted with all that related to the practical side of drugs and their preparations. He was a great scholar and linguist, and was the translator of works from many languages into German. It was whilst translating the work on Materia Medica by Professor Cullen, of Edinburgh, that the idea occurred to him of testing the action of cinchona bark on his own healthy body.

The result of this experiment was that it produced in him an exact picture of an attack of ague—that is to say, it produced a condition presenting symptoms *like* those of a state of disease it was known to cure. This led Hahnemann to test other drugs in the same way, and he found the law held good. Whenever a case of illness presents symptoms closely resembling those produced by a drug on healthy persons, this drug will be the remedy for the case. In the work of experimenting with drugs, Hahnemann obtained the help of a number of friends as well as of members of his own family. The results of these labours was the building up of one of Hahnemann's great works, the "Materia Medica Pura"—that is to say, the actual observed effects of drugs unadulterated with any admixture of theory or opinion.

In this work the symptoms actually produced by each drug on the experimenters are arranged in a definite schematic order for handy reference. Another discovery of Hahnemann's was the increased sensitiveness of patients to the action of a drug which is homœopathic to the case. This necessitated his giving a much smaller quantity of a drug for the cure of a patient than was required for the production of the like condition in a healthy person. This led to Hahnemann's invention of a graduated method of attenuating medicinal substances up to a high infinitesimal dilution. The recent discoveries in regard to radium and light treatment have familiarised the scientific world outside homœopathy with the power of infinitesimals. A full statement of the homœopathic doctrine is contained in Hahnemann's great work "The Organism of Medicine." His third great work is entitled "On the Nature of the Chronic Diseases."

Qualifying for the Profession. In this country at the present time anyone desiring to enter for the homœopathic profession must first obtain a qualification in one of the recognised colleges or universities. After graduation, the British Homœopathic Association, 233A Regent Street, W. (President, Earl Cawdor), arranges for him an academic systematic course of lectures on Homœopathic Materia Medica and Homœopathic Therapeutics during the winter session, and during the summer session of each year a further course of Homœopathic Therapeutics is given. Ample opportunities for clinical instruction and clinical work are always afforded at the London Homœopathic Hospital, Great Ormond Street, W.C., and at the homœopathic hospitals of Liverpool and Birmingham. In addition to this, much valuable instruction may be gained by watching the practice at such homœopathic hospitals as those at Bromley, Tunbridge Wells, Bournemouth, and elsewhere.

In addition, the British Homœopathic Association is sending young medical men to America every year to be instructed in the homœopathic colleges there. A further excellent means of becoming thoroughly acquainted with the details of homœopathic practice is by obtaining a resident medical post at one of the above-named hospitals.

The prospects of any capable man who possesses a good knowledge of homœopathic practice are much better than those of one who lacks it. The demand for homœopathic practitioners is very much greater than the supply. In cases where a start is made in a new district, the British Homœopathic Association gives its support to a fitting candidate until such time as he has been able to make his position secure. It never takes long to do this, so great is the demand among the laity for homœopathic treatment. This demand comes from all grades of society, from Court circles downwards.

THE VETERINARY SURGEON

By Dr. Gerald Leighton

There is only one portal to the ranks of veterinary surgeons—namely, the prescribed examinations of the Royal College of Veterinary Surgeons. No matter where the student enters and studies, the examinations are identical, and are controlled by this body alone. In this the veterinary profession differs from medicine, in the latter profession the

student having a choice of degrees or qualifications, any one of which allows him to practise as a physician or surgeon. In veterinary science, however, every practitioner must pass the M.R.C.V.S. (Member of the Royal College of Veterinary Surgeons), that being the only legal veterinary qualification in Great Britain.

The Veterinary Surgeon's Course of Study. The first stage is to pass the preliminary examination in general knowledge, just as it is in medicine. This has been recently altered and the announcement made that "Candidates not yet attending a veterinary college must take the Examination on the Medical Preliminary Standard at the January and April Examinations (1907), and also at all future dates." As we are writing for those who are prospective veterinary students, not for those already in the profession, it will be sufficient to draw attention to this important announcement as it stands, referring our readers to what has been already said concerning the medical preliminary examination. The list of examining bodies whose certificates of examinations in general education are accepted in lieu of the preliminary are similar to those for the medical preliminary. Full particulars of these may be obtained from the secretary of the Royal College of Veterinary Surgeons. A certificate of having passed all the required subjects in this examination before entering college entitles the student to present himself for his first professional examination.

The preliminary examination passed, the student has then to determine in which college he will take his course. He has the choice of colleges in London, Edinburgh, Dublin, Glasgow, and Liverpool. Before very long, in all probability, other universities will institute a faculty of veterinary science, as has been done in Liverpool. The choice of the college will doubtless be determined to a certain extent by the student's place of residence, the actual cost of the various classes in the various colleges not varying more than a few pounds per annum. Of course, if the student has to leave home and live in rooms, he must decide which place suits him best from the financial and other standpoints of living. Class fees amount to £20 a year, or slightly less, to which must be added books, cost of living, and examination fees. The whole course of study, extending over the minimum period of four years, together with the subjects for the four professional examinations and the fees payable, is shown in the following table. There are only two examinations held during the year—*viz.*, in England and Ireland in July and December, and in Scotland in May and December.

Final Examination and Prospects. Any veterinary surgeon who has been in practice for a period of five years or upwards who produces a certificate of fitness may proceed to the examination for the Fellowship of the Royal College of Veterinary Surgeons. This is a higher examination, just as the M.D. is in the sister profession. For this the candidate must write an original thesis, and defend this thesis for half an hour before the examiners. He must also undergo a written examination in veterinary medicine, surgery, hygiene, sanitary science, pathology, and bacteriology. This examination is held in May and December in each year. A fee of £5 5s. is payable on sending in the thesis, and on passing the examination and receiving the diploma a further fee of £10 10s. Having successfully passed his M.R.C.V.S. final examination, the veterinary surgeon has then to decide the important point

SCHEDULE OF EXAMINATIONS FOR VETERINARY SURGEONS

Examining Body. Diplomas. Time and places of Examination.	Subjects of Examination		Fees and Age Limits.
	Compulsory.	Optional.	
ROYAL COLLEGE OF VETERINARY SURGEONS. M.R.C.V.S. and F.R.C.V.S. Entrance. Edinburgh, Glasgow, London, Liverpool, Dublin.	English, including Composition, Dictation, Parsing, and Derivation. Latin, Grammar, Translation into English. Mathematics, Arithmetic, Algebra up to Simple Equations (inclusive). Geometry, Euclid, Books I. to III., with Deductions.	One of the following: Greek, French, German, Italian, any other modern language, Logic. Candidates not yet attending a Veterinary College must take the Examination on the Medical Preliminary Standard at the January and April (1907) Examinations, and also at all future dates.	£1 None
For M.R.C.V.S. First Professional. May and December. Edinburgh, Glasgow. July and December. London, Liverpool, Dublin.	Elementary Anatomy, Chemistry, Biology (Botany and Zoology).		£5 None
Second Professional. Time and place as above.	Anatomy, Physiology (Histology), Stable Management (Manipulation and Shoeing).		£5 None
Third Professional. Time and place as above.	Pathology and Bacteriology, Materia Medica (Toxicology), Hygiene (Dietetics).		£5 None
Final. M.R.C.V.S. Time and place as above.	Veterinary Medicine, Surgery, Obstetrics, and Meat Inspection.		£5 Registration Fee £1 21 years.
For F.R.C.V.S. May and December. London. Or by arrangement elsewhere.	Thesis. Written Examination on Medicine, Surgery, Hygiene and Sanitary Science, Pathology and Bacteriology.		Entrance £5 5s. Passing £10 5 years in practice

of which branch of his profession is to engage his attention. There is a wide choice. He may decide upon general practice in town or country, and in that sphere a good practitioner will make a good living, if not a large fortune. Corporation appointments as meat inspectors attract some. He may specialise, devoting his attention chiefly to dogs, or horses, or cattle, etc., and will find his services in high demand where valuable pedigree animals are concerned. A good veterinary surgeon in any well-known hunting district in England has every opportunity of making a good position. The hardest life is undoubtedly that of the country practitioner in a sparsely populated district where his clients are not too well off and his patients not sufficiently valuable to justify much expenditure upon them.

The Army Veterinary Department. Of recent years, especially since the Boer War, great changes have been made in the Army Veterinary Department, which now offers a good career to a certain number. The rates of pay and rules regarding the promotion and retirement of veterinary officers are laid down in the Royal Warrant for Pay, a copy of which should be obtained by intending candidates for the Army. The requirements demanded of candidates are these:

(1) Candidates for admission must make written application to the Secretary, War Office, London, giving the information required by Appendix I. A personal interview with the Director-General, Army Veterinary Service, will subsequently be necessary, and will be arranged by that officer.

(2) The minimum age of candidates is 21 years, and the maximum age 27 years, except in very special cases or on urgent occasions, when the latter limit may be exceeded. Candidates must be unmarried, and will not be accepted unless, in the opinion of the Army Council, they are in all respects suitable to hold commissions in the Army.

(3) Every candidate must be a member of the Royal College of Veterinary Surgeons, and pass an examination before a board of veterinary officers.

(4) He will be required to forward the following certificates, prior to examination: *(a)* a certificate of birth or other satisfactory proof of age; *(b)* certificates of moral character from clergymen or others in a position to testify, and whose evidence may be deemed satisfactory.

(5) The Dean or other responsible head of the school from which the candidate graduated will be asked by the Director-General for a confidential report as to his professional ability and general fitness to hold a commission in the department.

(6) If approved, he will be examined as to his physical fitness by a board of medical officers (Appendix II.), and if pronounced physically fit will then be eligible for examination.

(7) Examinations will be held on vacancies occurring, and candidates who obtain the qualifying number of marks will receive commissions according to the order of merit in which they pass.

(8) Candidates will be examined by the Examining Board, and the examination will be in two parts, written and oral, as follow:

WRITTEN

	Maximum marks.
Veterinary medicine (2 hours) ..	1,000
" surgery " ..	1,000
" hygiene " ..	1,000

(General papers referring to both horses and cattle, and embracing pathology in all its branches, surgical anatomy, and general and special hygiene.)

To qualify—50 per cent. in each subject.

ORAL

	Maximum marks.
Examination of horses, including soundness generally and certificates thereon, ageing, shoeing, the eye, and detection of lameness	3,000
Clinical diagnosis, the practical handling of animals and administration of medicines	2,000
Practical surgery and surgical anatomy	2,000

To qualify—50 per cent. in each subject.

An aggregate of 60 per cent. in all subjects combined will be required.

A candidate may be rejected if he shows any deficiency in his general education.

A candidate on appointment as veterinary officer will, on joining at Aldershot, be required to undergo a course of special training at the Army Veterinary School.

At the end of the course he will be examined, and if the examination be satisfactory and his general report good he will be retained in the Service; but should his examination be unsatisfactory, or his general report not good, his services will be dispensed with, in accordance with the last part of Article 431 of the Pay Warrant.

Rates of Pay in the Army. The substantive ranks of the officers of the Army Veterinary Department are as follow: colonel, lieutenant-colonel, major, captain, lieutenant. After passing the examinations the candidate is appointed a veterinary officer on probation for six months, after which, if satisfactory, he receives a commission as lieutenant at £250 per annum. The ordinary rates of pay are as follows (those of special pay abroad, with the army in the field, or in command at home, sick leave, retired pay, etc., will be found in the Pay Warrant):

Director-General, £1,200 a year — Inclusive of all allowances except field and travelling allowances.

	Daily. £	s.	d.
Colonel	1	15	0
Lieutenant-colonel	1	10	0
Major	1	0	0
" after 5 years' service as such ..	1	2	0
" " 10 " " ..	1	4	0
Captain	0	15	6
" after 5 years' service as such, provided he has served 3 years abroad	0	17	6
Lieutenant .. .. ..£250 0 0 a year			

The Indian Civil Veterinary Department. Lastly, we may mention this branch of veterinary work, in which the officers perform or supervise all official veterinary work in India, other than that of the Army, and are debarred from private professional practice in India. The duties are mainly educational work in veterinary colleges, horse and mule breeding, cattle breeding, and the treatment of disease. Applications for these appointments should be made to the Revenue Secretary, India Office, London, S.W.

Thus, the veterinary surgeon has an abundant choice of modes and places in which he may practise, and before coming to a decision he will do well to consult those who have experience of the branch he intends to pursue.

MEDICINE *concluded; followed by* DENTISTRY

continued from page 5264

THE BEST FOODS FOR POULTRY

Feeding for the Table or for Egg-laying. Some Typical Rations for Young Chickens and Adult Hens. A List of Suitable Foods

By Professor JAMES LONG

IN connection with the feeding of poultry the reader is referred to pages 2702-6, in which the principles of the feeding of livestock are discussed. Although this discussion refers in particular to the larger animals of the farm, the major portion of those pages may be applied with equal advantage to poultry. Not only have we provided a table of analyses showing the percentages of the various digestible constituents of foods, but those constituents are described in detail and their relative values compared.

The Hen's Carcase. In feeding poultry we are bound to observe the difference in size between the hen, and, let us say, the sheep or the bullock, the greater rapidity with which food is utilised, especially in the formation of the two materials of which the body of the hen is chiefly composed—fat and protein, which comprise nearly one half of the dry matter of the carcase; and the fact that she is an omnivorous feeder, eating animal and vegetable food with equal felicity. In passing, it may be observed, too, that the composition of the dry matter of the hen's carcase—we do not refer to fowls which have been fattened—is closely identical with that of the dry matter of the egg. As an omnivorous feeder, then, it is clear that the food supplied to poultry should be varied. In practice, however, we find that where one individual chiefly feeds his poultry upon maize, another selects barley, while a third may employ maize as hard food and barley-meal in the form of paste, which so many persons regard as an important feature in feeding, especially when it is supplied hot in the morning, having been mixed with skim milk, or the liquor in which meat or bones have been cooked.

Feeding Chickens for the Table. Food is supplied to poultry, in the first place, for the maintenance of their bodies, and next for the production of meat or eggs. Chickens which, after hatching, are intended for the table, should, like the calf intended for veal, be well fed from the egg forwards, every effort being made to induce growth accompanied by an increase of flesh. Where chickens are intended for laying purposes—and here we naturally refer to the pullets—the same form of treatment is not an essential; and yet the feeding should be equally careful, for the stronger and healthier the chicken the more robust and vigorous becomes the young fowl, and indeed the earlier she begins to lay. Success lies, however, rather in the direction of variation in the rations as between chickens intended for table and the pullets for laying than in the quantity of food supplied. The demand for fattened chickens, valuable as it is from a pecuniary point of view, is not a healthy one; but in his own interest the poultry-keeper must respond to it. The object is to send into the market at the earliest date young birds, tender and fat, for which he receives what we now regard as unparalleled prices, especially in the early season. We have noticed such birds priced at 10s. 6d. each in the West End of London, but they were the result of considerable labour and skill on the part of the producer.

Feeding Pullets for Egg-laying. The pullet intended for laying should be fed naturally, and supplied with all she requires, and the greater her freedom and the larger the quantity of insect life, grass, and clover she can obtain the better for her growth and strength. But the chicken for the table is, at a given age, which is more or less closely prescribed, caged and crammed with food, a large proportion of which consists of fat, and, having added to her weight sufficient for the purpose of the feeder, is killed and sent to market.

Food is rapidly appropriated by poultry, especially by young chickens, and there is little doubt that appropriation or assimilation are still more rapid and effective when the ration is mixed.

The Feeding Value of Milk and Bone. Although cereals are principally employed as food, pulse and other grains are occasionally supplied, together with milk and meat in some variety. The value of milk is noticeable in two directions. It is believed that the protein of animal food, as in the casein of milk, is better assimilated and employed in the economy of the fowl than the protein of cereals or pulse, and, further, that the necessity for mineral matter—especially for phosphates—is more readily met by meat and milk than by vegetable food of any kind. Where, therefore, cereals are employed—we especially refer to wheat, oats, barley, maize, and rice—the ration should be supplemented, especially in the case of chickens intended for laying, and thus raising to adult age, by bone supplied in one of its various forms. Here we would point out that bone should be fresh and unboiled. Bone contains two materials which are of great value to poultry—phosphate of lime, as essential in the construction of bone as lime in the construction of the shell of the egg; and the albuminoid matter which we will describe under the general term of protein, which is extracted by boiling, and which is the valuable constituent produced in the kitchen as the foundation of stock for soup. Boiled bones, therefore, should be avoided, and for a similar reason many brands of bone-meal or ground bone. The wisest plan is to obtain a crushing machine, which is now especially made for poultry-keepers,

and to break up into fine pieces bone fresh from the butcher. If bones are used with liberality, birds which are confined to pens or runs will need no special provision of materials containing lime for the manufacture of the shell, which weighs about 10 per cent. of the whole egg.

The Laying Hen Needs Lime. It has been shown by careful demonstration that under ordinary feeding conditions, the birds being kept in confinement, only about one-tenth of the lime in the eggshell was accounted for as having been obtained from the food, the remaining nine-tenths being extracted from materials chiefly composed of lime. It need hardly be suggested that the laying hen requires lime in much greater abundance than the chicken or the non-laying hen, and the remark equally applies to phosphates. It is found in practice, however, that all classes of poultry thrive better upon food which is rich in phosphates; hence, again, the importance of milk, bones, of meat, and of every class of food which is rich in these materials. Laying hens require about one ounce of fresh cut bone or meat daily, allowance being made for their size.

And here, again, it is essential to refer to the supreme importance of careful observation on the part of the feeder. In daily practice flocks of poultry are fed alike, almost without discretion, whereas both common-sense and experience suggest that not only size, but age and individuality demand special attention. Hens which have ceased to lay owing to age, weather, or moulting should not be fed upon the same ration as young birds which are laying. Large hens require more food than small hens, but for maintenance they require less per pound of live weight. In practice we have found that hens of average size require a quarter of a pound of heavy grain, such as maize, wheat, or barley, or its equivalent daily. This, equal to some 4 oz., experimenters have found to be almost precisely what laying hens require for the provision of heat, repair of waste tissues, the exercise of energy, and the provision of the egg. If we suppose that an egg laid by a good-sized hen contains 2 oz. of feeding matter, about three parts of which is water, it follows that the food consumed must provide for the elaboration of half an ounce of dry matter, which chiefly consists of yolk—largely oil—and albumin.

Heightening the Colour of an Egg's Yolk. There is every reason to believe that food is not accountable for the delicious flavour of the yolk of the eggs laid by certain hens, which resembles that of the guinea fowl, but that it may be perpetuated by selection in breeding, and by this process only. On the other hand, there is equal reason to suppose that the colour of the yolk is influenced by the food consumed—thus, where hens are deprived of green food, and especially of grass and clover, the yolk is often pale, whereas the yolk of hens at liberty in green fields is usually high in colour. Essential as green food is to hens, it is important to remember that they should not be allowed to consume too large quantities in place of grain or meat. The system of the hen demands food of a concentrated character, hence the importance of relying chiefly upon those foods which are usually supplied. The food consumed having been softened in the crop, is practically masticated, or very finely ground, in the gizzard, and, by the aid of the digestible juices, quickly assimilated, and, after providing for maintenance, converted into meat or egg.

The Albuminoid Ration for Poultry. The student of poultry feeding will do well to refer to the remarks on the albuminoid ration, page 2706, in which the principle of supplying the constituents of food in accordance with the requirements of the animal are explained. We need, therefore, merely point out that the nutritious matter of food is divided, minerals apart, into three groups—the fats or oils, the carbohydrates, chiefly starches and sugars, and the albuminoids (protein), which alone contain nitrogen, and which are therefore alone responsible for the production of the albumin of the egg, and the muscle, and other lean or nitrogenous parts of the carcase. In practice it is found that a ration composed of one part of albuminoids and five parts of carbohydrates and fats is followed by the best results. The method of calculation will easily be understood if the chapter we have referred to is carefully read, and if reference is made in the preparation of a ration to the analytical table which accompanies it. The foods which are rich in albuminoids, and which are chiefly used in feeding poultry, are meat, bone, peas, beans, lentils, malt combs, bran, linseed, cotton-seed meal or cake, clover, lucerne, vetches and sainfoin, the two latter being either green or dried.

Fats and Carbohydrates. The foods rich in oil or fat include linseed, linseed cake, decorticated cotton cake, the fat of meat, and, on a smaller scale, maize and other cereals, the best ricemeal, and maize germ meal. Foods rich in starch and sugar are common enough, and their employment may be almost essentially regulated by the market price. They include wheat, barley, oats, maize, rice, dari, buckwheat, groats, oatmeal, ground oats, fine sharps or middlings, sometimes described as toppings or fine dan.

Oatmeal and groats, together with the ground oats of Sussex, in which the husk is finely ground with the kernel, are valuable for chickens, especially when supplemented by fine-cut bone and mixed with new or skimmed milk; and here we may add that new milk is not only rich in fat, but especially rich in albuminoid matter, and highly adapted, either as a drink, or supplied in the form of curd to the feeding of chickens of all ages. Similarly, skimmed milk, although deprived of its fat, is rich in albuminoid matter, and is of great value when employed for mixing the various meals into paste, especially the cereal meals which are so deficient in albuminoids. The same remark applies to potatoes, which, rich in starch, although a bulky food, owing to their large percentage of water, are rendered much more valuable for feeding adult fowls when similarly mixed with skimmed milk and pulse meal.

Some Typical Rations and their Cost. No Englishman has accomplished better work in the poultry industry than Sir Walter Palmer, of Reading, who some few years ago established a poultry farm near Winkfield, in Berks, on soil which, chiefly pasture, consists of fairly stiff clay. Reference is warrantably made to the system of feeding, owing to the success which has attended the work, and which was shown for the first three years in published balance-sheets. A ration consisting of 1 lb. each of pea-meal, cracked maize, potatoes, and meat, 3 lb. of biscuit meal, and 2 lb. of swedes, the whole costing fivepence, sufficed as an autumn morning food for seventy hens, each bird thus receiving 2 oz. of food. The potatoes and swedes were steamed, the meat—horseflesh, costing a halfpenny per lb.—being added later, and subsequently the maize. The second meal consisted of 10 lb. of wheat, costing 8d.—this grain being steeped during hot weather—or heavy oats, these foods being distributed on the grass, or scattered among straw during hard frost, to induce the birds to exert, and thus warm, themselves in finding it. During autumn and winter the two rations practically cost 1¼d. per bird per week, or 1½d. where grit and lime rubbish, both being purchased, were added. The cost during the summer months was slightly less. During summer, when insect life is abundant, and when grass, clover, and other herbage are young and sweet, hens at liberty, like chickens, find a large proportion of their food.

Food for Very Young Chickens. In the arrangement of the feeding of chickens, no food is supplied during the first twenty-four hours by Sir W. Palmer's manager. The first food provided consists of breadcrumbs, fine oatmeal, and boiled eggs, followed next day by coarse oatmeal, boiled rice mixed with toppings, buckwheat, and broken wheat. Such is the ration supplied during the first fortnight, after which meat is added, and fine bone-meal mixed with the soft food. It was found by observations made in February, when feeding the chickens in a rearing house, where the only food consumed was that supplied by hand, that 28 youngsters, 8½ weeks old, consumed in one day 11 oz. of bruised oats, 14 oz. of rice, bone-meal, oatmeal and milk, 10 oz. of broken wheat, and 12 oz. of buckwheat. In another case, 32 chickens, 6½ weeks old, consumed 34½ oz. of the same foods, chiefly bruised oats, while 23 chickens, 2½ weeks old, consumed in the day 7½ oz. of bruised oats and 2 oz. or rice, bone-meal, oatmeal, and milk.

In feeding chickens intended for the table, between March and June, the system already referred to is followed by a course of three weeks' feeding in pens. At first the birds receive ground oats, toppings and skimmed milk. This preliminary feeding is followed by cramming with the same foods, to which ¼ oz. to ½ oz. of fat per bird is added per day. Sixty-four birds fed by the aid of the cramming machine on a particular day in July, when fat was not being supplied, consumed in the morning 20 lb. of milk, 12 lb. of ground oats, and 3 lb. of toppings; and in the evening, 18 lb. of milk, 10 lb. of ground oats, and 3 lb. of toppings, or 28 lb. of solid and 38 lb. of liquid food, practically 1 lb. per bird per day, scarcely one half of which was solid food. The value of this food, estimating milk to cost 4d. per gallon, the oats 1d., and the toppings ¾d. per lb., was thus 3s. 6½d., or less than ¾d. per bird per day, or 10½d. per bird during the 14 days of cramming.

An Example from the United States. It will be equally instructive to take an example from the United States, where poultry feeding is now conducted on an extensive and especially practical scale. Professor Jordan, remarking on this case, points out that a day's ration for 800 to 1,000 chickens in their second week, consisted of 4 lb. of cracked wheat, 2 lb. of oatmeal, 3 lb. of maize meal, ½ lb. each of buckwheat and wheat middlings, ground oats, and linseed meal, 2¼ lb. of animal meal, and 2¾ lb. of lucerne. For ducklings of three weeks old a ration consisting of 8 lb. of maize meal, 3 lb. of middlings, 2 lb. each of barley, linseed meal and fresh bone, 6 lb. of animal meal, and 3 lb. of green lucerne, might be similarly supplied, the birds being at liberty, and finding grit and lime rubbish for themselves.

We will now give a list of the foods which are especially suited to poultry.

Wheat. Wheat is a grain suitable for chickens on account of its size and its nourishing character, but, being deficient in oil and albuminoids, it should be given only occasionally. Tail wheat—that is, the small and broken grains removed from the bulk in the process of dressing for market—is most suitable, bearing the price in mind; but farmers, as a rule, prefer to keep this for the use of their own poultry.

Barley. Barley is also especially valuable, although, like wheat, it is deficient in both albuminoids and fat; but plump samples, especially as regards the price, are less valuable than smaller grain, which contains proportionately less starch. Tail barley, obtainable from farmers, is therefore suitable, but foreign barley, which is largely composed of husk, it is not advisable to buy, although this forms a very large portion of the composition of barley meal. When barley meal is used, it is preferable to buy the barley and have it specially ground. We know from actual demonstration that the barley meal of commerce is sometimes composed of the grindings of other grain, weed seeds, and refuse extracted from corn of various kinds in the process of dressing in the mill.

Oats. Oats are richer in fat than either barley or wheat, but are also deficient in albuminoids. The oat is, however, better balanced, especially where the sample is not too heavy, and consequently rich in starch. This grain is better supplied in the form of oatmeal or groats for very young chickens; or of ground oats, especially as prepared by Sussex millers, for chickens of larger size and for adult fowls. Oatmeal is slightly richer in starch and poorer in fats and albuminoids than the oat grain. It is, however, an especially good food.

Maize. Maize is now supplied in various forms through its by-products; the grain is

richer in oils than either of the cereals already mentioned; it is extremely rich in starch, but comparatively poor in albuminoids, and is not adapted for young chickens, except when cracked and given occasionally, or as a regular food for adult fowls, and the remark equally applies to maize meal. The germ of maize, however, although less palatable, is richer in albuminoids or muscle-forming matter, and extremely rich in oil, and may be used as an addition to those mixtures of meals which are poor in oil. The actual germ of maize contains 21½ per cent. of protein or albuminoid matter, 34 per cent. of starchy matter, and 29 per cent. of fat. The germ consists of about 10 parts of the original grain, the skin about 5½ parts, and the starchy matter and harder parts 84½ per cent. A material known as gluten meal, produced from maize, while containing about 50 per cent. of starchy matter, also contains 33 per cent. of protein; while an American food, known as gluten feed, contains slightly less protein and a similar quantity of starchy matter, but considerably more fat. These foods, although rich, and useful in consequence, are not altogether palatable to stock, but they may be employed in mixtures which are spiced, and so rendered agreeable to the birds.

Rice. Rice is a food which is so poor in fat and albuminoids, and so rich in starch, that it should be given in conjunction with a food like skimmed milk, in which it is best boiled or soaked. Rice meal, however, unlike the naked grain, is rich in oil, while it contains 50 per cent. more albuminoids than the whole grain and a smaller proportion of starch; for this reason, if pure, it may be employed with advantage, but care is needed in its selection.

Buckwheat. Buckwheat is a grain much relished by chickens, although it is not equal to the best cereals, being especially poor in oil and albuminoids, but it affords a useful change.

Dari. Dari, which is often given as a change food for small chickens, is rich in starchy matter, but relatively poor in other feeding constituents.

Ground Food. Of the various forms of ground food or meal, we may especially refer to fine *middlings*, sometimes known as *toppings* or *dan*. The true sample should be floury, and mix into a good paste, for there are various brands of sharps and shorts which are chiefly composed of the husk of the wheat grain. This food, mixed with skimmed milk, is excellent, and may be frequently used with advantage. *Bran* is sometimes used as a food for poultry, but it is not economical when it costs more than £5 a ton. A good sample is well balanced, except for the small quantity of fat it contains. *Pea meal*, which is rich in albuminoids, like *lentil meal* and *bean meal*, is useful for mixing with foods which are rich in starch, but these foods should be used in comparatively small quantities. Decorticated *cotton-seed meal* may be similarly employed when it becomes necessary to raise the fat and albuminoid percentage of a ration. Crushed *linseed cake* may be employed in the same way; it is an exceptionally rich food, though much more costly than the majority of poultry foods.

Green and Dried Fodders. Green and dried fodders, such as *lucerne* and *clover heads*, are always useful. They may be given to birds which are in confinement fresh in summer and dried in winter, having been plucked from the stalks for the purpose, for it should be remembered that as poultry require food in a concentrated form, the dried stalks are better removed, these being much less nourishing.

Roots. The *potato* is sometimes given to adult fowls, but owing to its large percentage of water (nearly 77 per cent.), and the fact that the residue is chiefly starch, it should be mixed after cooking with a small quantity of skimmed milk and a meal rich in albuminoids, such as that derived from peas, beans, lentils, cotton-seed, or linseed.

Roots such as *mangels* and *turnips* have little feeding value, but they are much relished by poultry, and a *bulb* cut in halves and placed in the run where birds are confined will assist in maintaining a healthy condition, and practically take the place of ordinary green food, such as cabbage or lettuce.

Meat and Fish Foods. With regard to meat and fish foods, a variety of which are on the market, it may be mentioned that animal meal sometimes employed by poultry keepers is extremely rich in mineral matter, of which it contains over 30 per cent., with 35 per cent. of protein, and 12 per cent. to 13 per cent. of fat. A useful form of meat meal contains a very small percentage of mineral matter, but 70 per cent. of protein, and a similar proportion of fat, while dried blood contains 34 per cent. of protein and 2½ per cent. of fat; this, however, is not rich enough in minerals. On the other hand, a dried fish food contains 30 per cent. of mineral matter and 48 per cent. of protein, with a small quantity of fat.

Milk and its Products. Foods prepared from milk are of the greatest value to the poultry keeper, whether for the feeding and rearing of chickens or of adult fowls. Rich milk contains some 3½ per cent. to 5 per cent. of fat, over 3½ per cent. of casein, and albumin, both of which are proteids and from 4½ per cent. to 5 per cent. of sugar. When deprived of its fat, the proportion of sugar and proteids is slightly increased, while the cost price is immensely reduced.

Whey, the residue of the cheese-room, only contains a small quantity of protein, but about 5 per cent. of sugar. New, or full milk, may be used for chickens to drink, or for mixing with their meal, while skim milk may be employed in the preparation of any form of paste, and thus for mixing with dry meals for fowls of all descriptions. The best method of supplying milk food to chickens is in the form of *curd*. A small quantity of rennet in a little water is added to milk at about 85° F. Having coagulated, the curd is drained—the surplus water is removed to a very large extent—until it is sufficiently solid to handle and to break up and distribute to the birds. There is no food so valuable as curd prepared from new milk, nor one better adapted to secure the rapid and healthy growth of young chickens, who may receive it until they have reached adult age.

Continued

TRUMPET, CORNET, & HORN

Construction and Characteristics of the Instruments. Scales. Intervals. Exercises. Transposition

Continued from page 5272

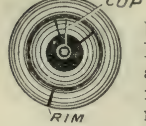
THE TRUMPET

By John Solomon, A.R.A.M.

Of trumpets there are six recognised varieties. First we have the "Bach," expressly employed for that master's works; secondly comes the slide instrument, rarely used nowadays; thirdly we have the C trumpet, identified with French concert orchestras; fourthly there is the B♭ model, employed in German and English orchestras, besides military bands; fifthly there is the E♭ trumpet, requisitioned for cavalry bands and other military purposes; lastly, for the concert platform, the coming instrument in this department is the trumpet in F. Whether for tone-qualities or facilities in manipulation, it surpasses in excellence the other varieties. From C, second space bass clef, to G, above treble staff, it produces a true chromatic scale. Beyond this range other notes can be articulated, but they are rarely written for by composers.

The F instrument thus has a compass of two octaves and a fifth. The length of brass tubing of the trumpet in F is about 68 in; without the F crook it is 72 in. in width. It is provided with three pistons. When these are pressed down and no crook or slide is employed, the first valve opens up about 10 in. of extra tubing, the second approximately 5 in., and the third about 14 in. These valves are fingered either singly, in couples, or all together. Only for the C♮, second space bass clef, are the three invariably pressed down. Lowering the first piston transposes the open sounds a whole tone, the second transposes them a semitone, and the third a tone and a half.

The Mouthpiece. The mouthpiece has an important influence on the tone; it therefore merits consideration. The shape of the rim, cup, and bore each has a material effect. If the rim is too narrow, it is apt to cut the player's lip and fatigue him quickly. It should never be less than $\frac{5}{32}$ in. in diameter. The bore must be hemispherical. If too deep, high notes will be awkward to obtain. There is no standard pattern for depth, no two players having identical lips; the ½ in. generally suffices. From the cup, the bore augments in diameter, so as to fit the tubing of the instrument. Medium gauge of bore should be chosen by the student, although certain lips get a better effect from a small gauge, whilst others excel with a large one. If, however, the bore is too large, upper notes become difficult, whilst if it is too narrow, the low notes suffer.



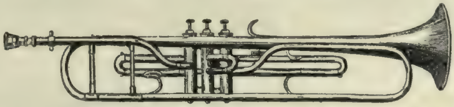
Tone Delivery. The French term for mouthpiece is "embouchure" This word is applied in English to indicate the method of blowing or the efficiency of the lip. In their natural state, a beginner's lips are helpless at the trumpet. Their nerve-sense has to be specially trained. This is only possible by constant practice, until the ganglions are so cultivated that the nerve-fibres respond instantly, by contracting or expanding, at the will of the player. Ordinary soft lips cannot give a true embouchure. The process of strengthening necessitates persevering study. To produce a musical sound from the trumpet, slightly part and draw back the lips without distending the cheeks. Place the mouthpiece of the instrument against the lips, covering more of the upper than the lower labium.

Avoid pressing the mouthpiece on one side of the mouth. Some beginners form their embouchure in this way. It not only looks bad, but should be avoided for other reasons. The proper place for it is at the centre of the lips. Press the mouthpiece gently. Without removing it from the lips, draw in the breath at the corners of the mouth. The first note obtained should be C, first ledger line below staff, treble clef. To produce that tone correctly, withdraw the tongue slightly from the lips with a quick movement, as if expelling a particle of fluff from the tongue-tip. For this note no pistons should be used. If the blowing is done judiciously, a displacement of the air will be caused, and the correct sound result. Practise this C several times. Try to get it more and more distinctly. Gradually, as the lips strengthen themselves, so will the tone improve.

The Harmonic Scale. In the F trumpet there are eleven open notes, or natural harmonics, as in Example 1.

Here the sixth note is flat and the tenth sharp. By the use of the first piston these sounds come in tune with the others. Other notes are obtainable, but are not required in written parts.

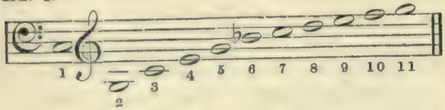
For the purpose of altering the key in which a piece is printed curved tubes are inserted into the trumpet. These are called crooks. According to their length, so are they lettered. First we have the F crook, 4 in. long; secondly there is the E♮; thirdly, the E♭; fourthly, the D♮, followed by the D♭, C, B, B♭, and A. Each one thus descends half a note at a time from the F, an extra length of tubing being added and coiled, for the sake of convenience, oblong fashion. In all, there are ten crooks



THE TRUMPET [Mahillon & Co.]

written for by composers. The D♭ and B♮ crooks are rarely used, and the majority of them

Ex. 1.



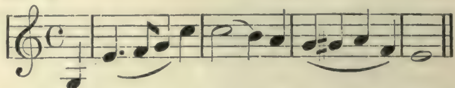
are seldom employed, since the player finds it more easy to transpose without their aid. The student should therefore learn to play with the F crook only, transposing the music by means of the pistons when other crooks are indicated. This is the safest plan. The only crooks usually made, therefore, are the F, E♮, E♭, and D. If those for other keys are required they have to be manufactured specially.

Valve Mechanism. Valves, or pistons, were unknown before the year 1814. Prior to that time the trumpet was simply a coiled tube enlarged at the bell-end. Towards the close of the eighteenth century a slide was added to the trumpet, working in a reverse direction to that associated with the trombone, being drawn towards, instead of extended from, the player. Nevertheless, a good chromatic scale could not be produced. The slide was insufficiently long to give the low A♮, A♮, and C♮. F♮, also, was too sharp. Nowadays, instead of the slide, we have three pistons. When pressed down separately or together, these are capable of rendering a perfect chromatic sequence. Each piston gives parallel harmonics to those sounded when no piston is employed, the same notes being heard but in a different key. A similar effect results when the pistons are combined, whether the first and second, the first and third, the second and third, or all three are put down together in order to lengthen or shorten the passage of air in the tubing. With the first piston down, the series already given is reproduced, but lowered in pitch a tone. Instead of F, the key thus becomes E♭, and the sixth and tenth degrees need correction in the same way as when the open harmonics were sounded without using the pistons. Releasing the first and depressing the second piston, the same series, as the air-column is shorter, becomes a semitone higher. So the natural key is now E, with four sharps. If only the third piston is pressed down, the tone is lowered a third from the open series. The key is, therefore, D♮.

These results should be understood clearly, as they introduce the subject of transposition. So the beginner must bear in mind that the trumpet, when open, is in F; when the second piston is down it is thrown into E; that the first makes it E♭, and the third D. Pistons are here, it will be seen, taking the place of crooks.

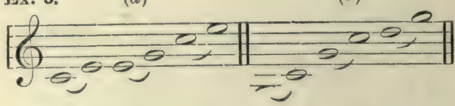
Slurring and Phrasing. Slurring implies, when playing on a wind instrument, making the sound glide from one note to another without fresh impetus from the tongue. This effect is indicated by a curved line above or below notes required to be linked in such a manner, as in Example 2.

Ex. 2.



When a slur is not marked, notes, in trumpet playing, have to be tongued, as already described. For the beginner, difficult intervals to slur, whether open or with pistons, are thirds, fourths, fifths, etc., as in the following example.

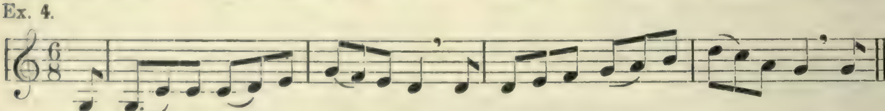
Ex. 3. (*a*) (*b*)



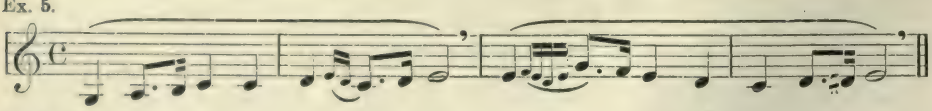
For them, therefore, special practice is needed. Phrasing comes almost under the same heading in performance as slurring. The difference is that the student must understand the correct moment for taking a breath when rendering a musical sentence. Those places are shown by commas in Example 4.

It will be seen here that a slur is included also in each phrase. If these slurs were omitted, all the notes would have to be tongued. This, in solo playing, would give a rough and staccato effect. Another way of writing a phrase containing a slur is shown in Example 5.

Ex. 4.



Ex. 5.

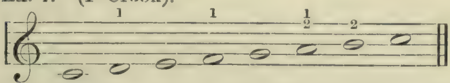


Ex. 6.

The curved line above each of the two bars, connecting the notes, implies that the tongue must not be used too freely. The phrase will be broken up if breath is taken at other points than those marked. As regards the slur placed under the notes, those not so linked must be tongued, as shown in Example 6.

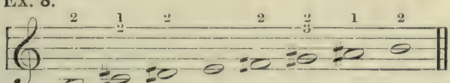
Transposing. To the beginner, one of the first puzzles is to reconcile a note indicated in the written music with a different note sounded by the trumpet. Thus, G, written on the second line treble clef, played on a B♭ crook, transposes itself a fifth lower to middle C, as do all the other notes when that crook is indicated. If the F trumpet is crooked in E♮, the same written note, G, when played, becomes F♯, a semitone lower, an effect more conveniently given by depressing the second piston. If the notation indicates an E♭ crook, the player—or the instrument—transposes a note lower. The G then becomes F♮, and so on. Should the part be marked in D, it must be transposed a third lower. As we have shown, each successive crook lowers the pitch half a tone down to A♮. The best way to learn to transpose trumpet music is to take a scale and start in F. With this F crook, practise an octave in C major, putting down the first and second pistons on the second, fourth, sixth, and seventh degrees, thus:

Ex. 7. (F Crook).



If these notes were preceded by the words "E crook," that would necessitate transposition a semitone lower, when the sounds would be

Ex. 8.



Thus, the scale becomes B♮. The occurrence of five sharps may make transposition appear difficult. To put the crook into F♭ would make it extremely difficult to transpose quickly. It would bring all the notes into flats, so this is better left alone and the E♮ that is written for only used. If the same part is marked "E♭ crook," the notes have to be transposed a tone lower from F. Thus, the starting note, originally C, becomes B♭, and that key has two flats. When the D crook is indicated, transposition likewise must be a minor third lower; with the C crook a fourth, B♭ crook a fifth, and the A♮ crook a fifth and a half, or minor sixth, lower. Although an exceedingly awkward transposition, the latter is frequently employed by modern English and Russian composers. British musicians often write for the trumpet in B♭ and A♮, because there are few F trumpet players and many B♭ performers. This not only saves the latter the trouble of transposing, but keeps parts from being disfigured with transposition marks. The F trumpet student is advised at first to practise perseveringly very low scales. In this way he can familiarise himself with transposing the music, using the pistons according to the indications for the different crooks. The scale of C will soon become familiar in every key if he does this. Then he should take a short, easy exercise and practise it in the same way. Next, he is recommended to get an oratorio trumpet part and transpose that also into the different crooks. With average ability, in a short time the result will be satisfactory. We give, as an illustration of such simple transpositions, a few bars on open notes only [Example 9].

To transfer these sounds from F into E♮, depress the second valve. This lowers the pitch equally half a tone. The effect, therefore, is as shown in Example 10.

The same passage "crooked in E♭," a note lower than F, would begin on D♮. Therefore, put down the first piston. As in the first instance all the notes were open, the same sequence will now be obtained. But the D (written on the fourth line) sounds flat with the first valve down, and the effect is better open. As it is then the natural open C on the F trumpet, it follows that it must be in tune for the D crook. Now try the crook in C. Begin on B♮, and transpose a fourth lower. For this series the piston must be used, otherwise the notes will not be in tune, and will sound too sharp.

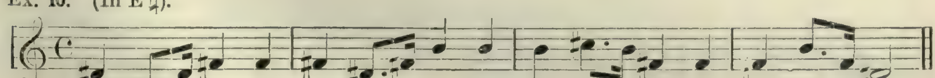
For the B♭ crook, transpose a fifth lower, beginning on A♮. The student will find the study interesting if he tries short exercises in the same way.

Exercises. So far, not many tutors have been published for the F trumpet, as its beauties have hitherto not been fully appreciated. The exercises on the next page give, first, the fingering of the entire range of the chromatic compass, flats in descending being manipulated in the same way as sharps in ascending [Ex. 11]. It is of great importance, in order to get smoothness and the ability to sustain the tone of the instrument, that slow

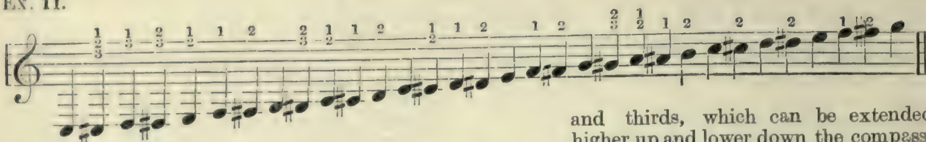
Ex. 9. (In F).

etc.

Ex. 10. (In E♮).



Ex. 11.



Ex. 12.

Ex. 13.

Ex. 14.

scales should be practised carefully every day. Although the beginner will not, of course, be able to negotiate extremely low or high notes, these will not present so much difficulty when the embouchure has been strengthened by diligent study. Ex. 12 can be fingered by reference to Ex. 11, and extended an octave higher by blowing with a firmer lip. It is merely the normal diatonic scale, and should be transposed into other keys. To acquire facility in the accurate articulation of any sound which occurs in a musical phrase when reading at sight, constant exercise in the practice of intervals is essential. Here Ex. 13 deals with seconds and thirds, which can be extended higher up and lower down the compass. With its sharpened F's Ex. 14 indicates the key of G major. Ex. 15 deals with fourths, Ex, 16 with fifths, which, although unmusical when blown consecutively, are useful to be able to attack at sight without hesitation. Ex. 17 gives sixths, Ex. 18 sevenths, and Ex, 19 is an octave study. Of all intervals, that which separates eight notes is the most interesting, since it represents the most perfect consonance in music. In painting, it is as if one saw a picture side by side with an exact facsimile reduced to half the original size. The tone-relationship of the higher and lower sounds are the same, but the vibrations, owing to the greater force of the breath, are more rapid in the octave above than in that below.

Ex. 15.

Ex. 16.

Ex. 17.

Ex. 18.

Ex. 19.

THE CORNET

By John Solomon, A.R.A.M.

The cornet-à-pistons, introduced about the year 1850, are now common to all military and brass bands, as well as concert orchestras. The cornet differs from the trumpet, not alone in appearance but in tone, its tubing being of wider gauge, and conical rather than cylindrical. It is usually modelled in B♭. Cornets are also made in C, but are only purchased by amateurs, to save transposition when accompanied by the piano. The instrument is of brass, the length of the tube being about 54 in. This gives the natural harmonics of B♭.

The cornet is provided with three pistons. These, as in the trumpet, lower or raise the pitch of the open notes according to the way they are employed. When the first piston is depressed, it transposes the open G, second line treble clef, a tone lower, to F. If the second piston is put down alone, the G is transposed half a tone, to G♭ or F♯. The third piston, by opening up more tubing, lowers the G an interval of a third, to E♮. The tone of the cornet is pleasant if not overblown, as in very loud playing. Owing to such a tendency, the instrument has received a bad name. Nevertheless, an artist can make its quality expressive and most delightful to the ear. Although the cornet can be made to sound in a way closely resembling the orchestral trumpet, there is, as a rule, a vast difference between the effect of the two instruments, on account of the dissimilarity in their tubing. To begin with, the B♭ cornet is pitched a fourth higher than the F trumpet.

But when crooks are placed on the latter instrument to lower the tone, this sounds more mellow, owing to the length of the air-column. On the other hand, as the shorter tubing of the cornet produces a tone of a higher pitch, it is brighter and more brassy. So the trumpet, if made above the key of F, would lose its proper character through shortening the air-column. Be careful, when purchasing an instrument, to see that it is free from faults, such as, usually, cracks, bad corks, wrong springs, or leaky valves.

The Mouthpiece. Much depends upon the shape of the rim, cup, and bore of the mouthpiece. The rim should neither be too wide nor too narrow; medium size is best. The cup must be conical but not shallow, like that for the trumpet. When buying an instrument, try several mouthpieces, and get that most suitable. At first there may be some difficulty in this. If the rim is not plated, it must be kept scrupulously clean. Before putting away the cornet, always wipe the mouthpiece carefully. See that there are no green spots on the brass. If they appear, they are caused by verdigris. Should the lips be sore, the result may be serious, and it is far wiser to purchase a plated mouthpiece. When once simple notes can be obtained with ease on the mouthpiece selected, practise steadily with it until the lips form a good embouchure. When this is once obtained, no after-adjustment will be necessary, as is the case with reed instrument players.

THE CORNET [Mahillon & Co.]

Tone Production. The method of producing sound from the cornet is the same as that for the trumpet. The first note to be obtained without touching the pistons is G, second line treble clef. Then get the C below the G and the octave C above. Sustain such sounds whilst mentally counting four very slowly. The other open harmonics should then be practised. When the open notes can be produced with ease, the pistons may be used. Try them singly at first.

Putting down the first piston, get the F, first space treble clef, clearly. Then sound B♭ on the third line above. Follow it by the octave B♭ below, and so on. In the same way obtain the harmonics from the second piston only. When these have been accomplished the student will be able to play the scale of C, using the pistons. What is known as the embouchure (described in the article on the Trumpet) signifies the flexibility and power of the lip in eliciting any sound required. Having acquired the ability to play the scale in C, if other scales together with exercises are regularly practised, the lip will strengthen gradually, and a good embouchure result. Avoid distending the cheeks.

Natural Harmonics. Owing to the air-column being shorter than in the trumpet, the cornet has a more limited compass [Example 1].

Except by great soloists—and then only for show purposes—the fundamental harmonic, or bottom C, is never used. Again, No. 7 (B♭) is not fingered as an open note, its effect being better when played with the first piston down. The extreme harmonics, Nos. 9 and 10, are seldom employed. Exceptional players, however, get even higher sounds than these. But the normal compass of the cornet is from F♯, on third ledger line below treble clef, up to C, on second ledger line above the staff. Only on rare occasions is the D above required.

Shanks. In place of the crooks on the trumpet, the cornet has two shanks. These are in B♭ and A♮. An A♭ crook was formerly used, as well as a G crook. These are now obsolete. As the cornet is modelled in B♭, the B♭ shank can scarcely be called an addition. It is a part of the instrument, but its use is convenient. It saves the player's face coming in contact with the body of the instrument. Without this shank, the cornet would be nearly half a note sharper in pitch. The A shank, being longer, transposes the instrument half a tone. Middle C, when the B♭ shank is adjusted, thus gives B♭ on the piano. The same note, with the A shank, sounds A♮ on the keyboard. Flat keys are generally played most easily with the B♭ shank, and sharp keys when using the A♮ shank.

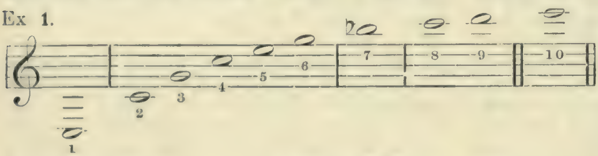
Valve Mechanism. The use of pistons came in about the year 1814. In 1832 an instrument appeared called the stop-trumpet, or cornopean in B♭. This gave the natural harmonics. It had three valves, or pistons, and the

power of lowering the open notes six semitones, as in the valve trumpet. To-day the first piston, when pressed down, transposes a whole tone, the second a half-tone, and the third lowers the open sound a third. Yet this is not always the case. For example, certain notes in Example 2 can be obtained by pressing down the first valve.

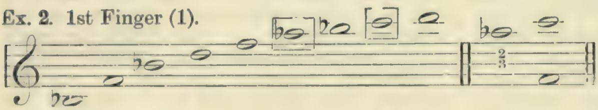
The notes bracketed on the sixth and eighth degrees, not being in tune, are better produced when the A♭ is fingered with the second and third pistons together and the C is played as an open note without touching the pistons. When the second valve is lowered, the series shown in Example **3** results.

Here, G♯ and C♯, not being in tune, are fingered respectively by use of the second and third and first and second valves. When the

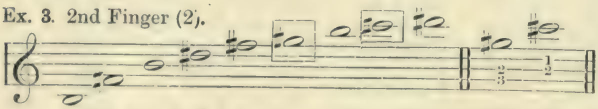
Ex 1.



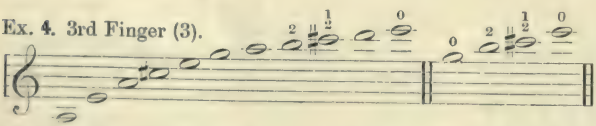
Ex. 2. 1st Finger (1).



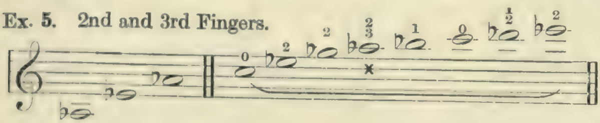
Ex. 3. 2nd Finger (2).



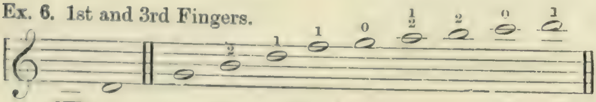
Ex. 4. 3rd Finger (3).



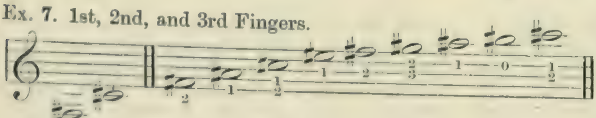
Ex. 5. 2nd and 3rd Fingers.



Ex. 6. 1st and 3rd Fingers.



Ex. 7. 1st, 2nd, and 3rd Fingers.



third piston is lowered, the sounds indicated in Example **4** can be obtained.

In this series, four notes need tempering. By the alternative fingering indicated they are produced correctly. When the second and third pistons are pressed down, the eleven sounds shown are possible, but as, after the first three are obtained, the others are not in tune, it is better to finger these in the way marked in Example **5**.

When the first and third pistons are depressed, the notes indicated in Example **6** can be sounded.

Here, again, after the first two, the others are better fingered in the usual manner. When the three valves are pressed down, the harmonic series shown in Example **7** is obtained.

As will again be seen, only the first two notes in this sequence are satisfactorily produced by all three pistons. The others should be fingered as marked. In the next example, as a guide to the student, we show the entire chromatic scale, or series of notes elicited from the cornet. Flats, in descending, are fingered as are the sharps in ascending. The five highest notes are seldom required. Nevertheless, we give them, since modern composers think little of trespassing beyond the recognised compass. Beginners, however, should not, in playing, venture beyond the top C [Example **8**]. If they do they may injure their lips.

Slurring and Phrasing. As the cornet is a solo instrument, correct slurring and phrasing upon it are even more important than in trumpet playing. As explained under Trumpet, a slur is a line placed over or under certain notes, linking them together, so that they are rendered smoothly [Example **9**].

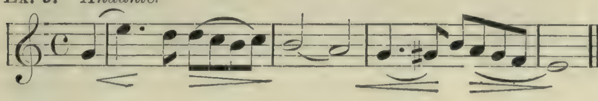
When a song is adapted as a cornet solo, study the words. If these are understood and remembered, the slurring will be assisted, and the piece performed as it would be sung, the player taking breath and phrasing in the same way. Slurs on open notes, as also those given by valves, will be found difficult at first. Especially is this the case with intervals of the fifth and sixth, as in Example **10**.

For the mastery of such difficulties, several weeks may be necessary, but unremitting practice will overcome them. Every fresh slur, however, may not admit of a fresh inhalation, because one breath has to suffice for a whole phrase, or musical sentence. Slurring, therefore, is subordinated to phrasing, although the former bears an important part in a long passage in which many notes may be slurred, the others being separately tongued. To phrase well, the student should endeavour to sing upon the instrument. This is impossible without paying constant attention to the art of phrasing. Unless a solo is phrased, it is apt, on the cornet, to sound vulgar. Instead of being vocal, the

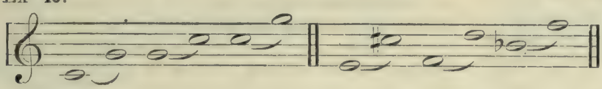
effect is harsh and crude. So the breath must only be taken when a phrase ends, or before it begins. To do this artistically needs experience. In some cornet music, phrase marks are printed. In the majority of solos this is left to the judgment of the performer.

Ex. 8.

Ex. 9. *Andante.*



Ex 10.



Transposition. Cornet players in an orchestra are expected to be able to transpose at sight. Horn and trumpet parts are frequently handed to them by the conductor to interpret in this manner. The beginner, therefore, is advised to accustom himself to transposing any scale or small piece. First transpose a note higher, then two notes, and so on up to a fifth above. Supposing that the trumpet part to be read by the cornet is crooked in C, the cornet should then have the B♭ shank. With this on, read a note higher. This makes the key D, with two sharps, instead of C, without sharps.

Remember, always, when accidentals occur that sharps must be read as naturals, naturals as sharps, and flats as naturals. Think of the key into which the music is being transposed. As the trumpet part crooked in C is being rendered by a cornet in B♭ a note higher, it must be borne in mind that every F and C in the key of D is sharp, the E♮ and B♮ in the trumpet parts becoming F♯ and C♯ on the cornet. If the trumpet is crooked in D♭, and the cornet is in B♭, a minor third higher, C, third space treble clef, will become E♭ on the fourth space, and that key has three flats, B, E, A. If the trumpet is crooked in D♮, the cornet must then have on the A shank. The transposition, therefore, will be a fourth higher, and C on the third space will then be read as F on the fifth line, with one flat, B. Here the note F, whenever it occurs in the trumpet part, represents B♭ in the cornet.

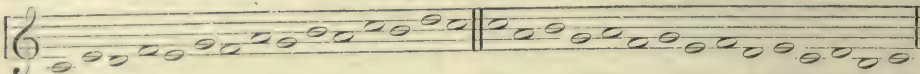
If the trumpet is crooked in E♭, put on the B♭ shank. Read a fourth higher, as in the last instance. If the trumpet part is crooked in E, use the A shank and read a fifth higher. C, third space, then becomes D above staff, and G major has one sharp, F. If the trumpet is crooked in F, adjust the B♭ shank. Read a fifth higher. The same sounds will result as in the last instance. It will therefore be seen that, in transposing a fourth and a fifth, both crooks, used alternately, give the same tonal effect.

When horn parts have to be transposed, it is necessary to read below instead of above. To do this most players mentally transpose the notes upwards, and play them an octave lower, since the horn, having nearly double the length of tubing of the cornet, voices all notes at a deeper pitch. Thus, if C, third space treble clef, is written for the horn crooked in F, to render suitably that note on the cornet the B♭ shank is affixed. The sound is transposed mentally a fifth higher, to G above the staff, and played an octave lower; or it may be read at once a fourth lower than written. In either case the sound heard is G on the second line.

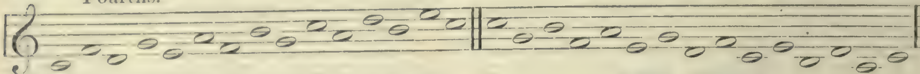
As trumpet parts have to be transposed upwards, the majority of cornet players, when horn parts are given to them, find it easier to make, mentally, the usual ascending transposition and then play an octave below, rather than transpose down at once. If both methods are attempted, momentary forgetfulness in reading at sight may lead to a blunder. Yet there should be no more difficulty in transposing down than in transposing up. It is only a question of practice. To acquire equal facility in either method, the student must start at an early age. He is not likely, otherwise, to master both principles in a way to be depended upon. Therefore, practise systematically both methods. Begin, however, by transposing each note in the scale of C, first one tone, then three tones, a fourth and a fifth higher. If transposition is neglected at the beginning of cornet study it is more difficult to acquire later. Its importance for professional purposes cannot be too much emphasised.

Studies. The cornet method most in use is that by Arbon. It begins in the simplest way, and advances gradually to the most difficult studies a player is likely to need. Tutors by Kosleck, Bonniseau, Forrestier, and Saint Jacomb are well known. The latest and best publication at the time of writing is by Hermann Pietsch. It is published in English as well as German, and is issued in two parts. The beginner is advised to play all exercises very slowly at first. Make sure that each note is correct in pitch and of good quality. Attention must be given daily to mastering the scales. Interval practice should follow. This must be done systematically. From the note C, first ledger

Ex. 11. Thirds.



Fourths.



line below staff, play in intervals of thirds, fourths, fifths, etc., up to octaves [Example 11].

If the student desires to excel, the study of intervals is essential. He must get accustomed, first, to hearing the sounds. As one piston produces several sounds, the ear must detect the right one, and the lip blow it instinctively. In this matter beginners are frequently careless. The habit easily grows upon them. Unless mistakes are pointed out, they are themselves ignorant that wrong notes are being sounded; therefore, begin all new exercises slowly and listen carefully. When sure that the notes are correct, the time can be accelerated. Transpose the same exercises into other keys, always playing slowly at first. Afterwards, the semibreves can be played as minims, then crotchets, quavers, or, finally, as semiquavers. When the student is sufficiently advanced for solo playing, slow melodies, such as easy songs, are advised. These, and other simple cornet pieces, can be obtained cheaply.

Double and Triple Tonguing. Double tonguing implies two notes repeated quickly, as if the syllables "tu-ku, tu-ku" were pronounced [Example 12].

Ex. 12.

Some players reverse the words.

To triple tongue, or repeat three notes rapidly, the syllables employed are "tu-tu-ku." Some teachers prefer "tu-ku-tu," but the sounds are surer and more even with the former method. Again, begin slowly. Try this example:

Ex. 13.

When these notes are properly sounded, beginning in slow and ending in quick time, and are articulated equally, another note should be treated in the same way until triple-tonguing is accomplished on every degree of the scale.

As the cornet is the leading brass instrument in a military band, there is a tendency for many beginners to take up this most popular of wind instruments. Thus the supply of players often exceeds the demand; but for orchestral engagements conductors naturally select only recognised artists of proved ability.

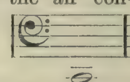
In conclusion, the student is advised not to be in a hurry. To become a first-class cornet player is a long and arduous undertaking. Great care must be exercised against the contraction of bad habits. When beginning a new study, four long beats should be counted on slow notes, to make sure that the sounds are correct.

THE HORN

By Paul Corder

Before taking up the study of the horn (it is also known as the *French horn* and the *valve horn*) the student should understand something of the principle which underlies the production of sound from those brass instruments of which the horn, trumpet, and trombone are the most important types. All the instruments referred to, besides many others, consist of a tube of metal (brass being most frequently used) of conical bore—that is, larger at one end than the other. Let us inquire briefly into the acoustical properties of such tubes.

Taking one with a length of 8 ft., it is found that, on putting into vibration the air contained within the tube, the note



is produced. This is termed the *fundamental* note of that length of tube, and were it the only note capable of being produced from it, the tube would be of little use as a musical instrument. But it is possible to make the column of air divide into two equal parts, each half vibrating independently; the note now sounded is the C an octave above the previous sound. Furthermore, the air-column can be made to vibrate in thirds, quarters, fifths, sixths, and so on, the notes produced in each case being shown in the illustration at the top of the next page.

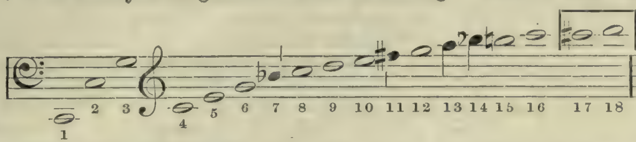
Those notes written as crotchets are imperfectly in tune, and the last two are very difficult of production.

This series of notes is termed the scale of natural harmonics, and constitutes what are known as the open notes of the horn.

Now we may leave generalities and come to a more particular account of how these facts apply to the horn. The tube of which it is composed is, on account of its extreme length, coiled up into a convenient form. One end opens out abruptly into a wide "bell," the other is fitted to receive the mouthpiece or extra lengths of tube. The mouthpiece is a conical brass tube, the exact shape and bore of which varies according to circumstances; for facilitating the production of the higher harmonics a slightly smaller bore is advisable than would be preferred for the lowest notes.

The Crook. It will be seen on reference to the table of harmonics that only a limited number of notes is possible on this instrument, and if the music should be in any other key than C, still fewer notes are available. This drawback was partially overcome by the use of a series of extra coils of tube, called *crooks*, which, by adding to the length of the horn, lowered the

pitch of the fundamental note and consequently of all the harmonics to a corresponding extent. Thus—the body of the horn has a length of 7 ft. 4 in.—by adding a tube about 8 in. long,



called the C alto crook, the series of notes already given will be produced. A crook 55 in. in length will cause the whole series to sound a fifth lower; this is called the F crook (F being now the fundamental). One in C basso increases the length to 16 ft., and lowers the pitch a whole octave. In the same way crooks of any length can be made to pitch the horn in whatever key is required.

Now, since the pitch of the notes is determined by the crook in use at the time, the player blowing the same relative series in any case, the custom arose of writing always for the horn as if in C alto, previously directing which crook was to be used. This saves the player the trouble of transposing, although it is woefully puzzling to the student to find the written notes meaning anything and everything at random. For this reason the matter has been explained at some length, as, since the modern innovation of valve mechanism, the older customs of crooking and transposing seem useless and meaningless; for the horn in use at the present time has none of the drawbacks attendant on the old "hand horn," as it was called, the gaps in the harmonic series having been filled in by means of an ingenious mechanissm which may now be briefly described.

A short length of tube is interpolated in such a way that, on depressing a piston attached thereto, the air is diverted through this extra tube in the course of its passage through the main coil of the horn. This is, in effect, temporarily increasing the length of the horn and lowering its pitch. On raising the piston, this extra tube is cut out of the circuit, and the original note restored. The modern instrument is provided with three of these devices, the first lowering the pitch a whole tone, the second a semitone, and the third three semitones, while any two can be used in combination or all three together; this last will lower the pitch to the extent of six semitones. It will now be readily understood how a complete chromatic scale can be played throughout the compass of the instrument.

So far we have spoken only of what the horn is capable; it remains now for the student to learn how it is possible to set in motion this column of air so as to produce any note required of the harmonic series.

VALVE HORN

The illustration shows a valve horn by Cortois and Mille. The coil marked A is the F crook, B is the mouth piece, the piece marked C is made to slide out in order to tune the horn to the exact pitch in use. If the course of the tube is followed from the bell, it will be seen to divide into two at H. This is not actually the case, as H is merely a strut to strengthen the pipe, and has no air-passage through it. The three pistons are numbered 1, 2, 3, and attached to them are their tuning-slides, marked respectively D, E, F.

The horn is held thus: the little finger of the left hand is passed under the hook G (in some instruments a ring is substituted), the other three fingers are thus brought into position over the three pistons, while the thumb is passed through the coiled tube and braced in a convenient position. The right hand is to be arranged as compactly as possible, the fingers close together, the tip of the thumb resting along the front of the forefinger, the whole hand slightly curved, and then inserted in the bell of the instrument as far as it will go.

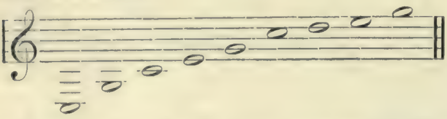
The important matter of the arrangement of the lips, or embouchure, as it is termed, now claims attention. A description of this is anything but easy. It may, however, be stated that it is useless to blow through a horn as you would through a whistle; neither should the cheeks be distended; on the contrary, they must be drawn in until the muscles on either side of the mouth are felt to be exerted. The lips are drawn together so that the air issues from them by a small aperture under considerable pressure, which pressure is regulated by the muscles of the cheeks and lips. The tongue and the upper teeth form a kind of valve, by means of which the compressed air can be retained in the mouth and lungs independently of any assistance from the lips. By pronouncing the syllable "ta," a thin stream of air will be released and allowed to issue from the lips.

A first attempt to produce a note from the horn is fraught with considerable uncertainty. Very possibly no sound at all will be forthcoming, but by careful experimenting, and making slight alterations between the relative positions of the lips and the mouthpiece, a sound of some sort will eventually evolve itself. We want, for a first attempt, to produce the note C, first ledger line bass clef, sounding, of course, a fifth lower if the F crook is being used. Let the student keep this sound in mind, and try to reproduce it. It is more than probable that he will make some entirely different note, perhaps B♭. This is caused by too great an air-pressure; leave the lips and cheeks looser, and try again. It will not be long before he attains the adjustment necessary for the required sound. Having

gained this first step, a very slight increase of pressure will give E, first line treble clef, and a little more the G above, and with these three notes the student should rest satisfied for the first lesson, turning them into an exercise, of which the following may be taken as a specimen :

When a certain amount of mastery over this and similar exercises has been attained, the compass may be extended by the addition of C, third space treble clef. The greater pressure required for this and higher notes is obtained partly by tightening the lips and compressing the cheek muscles, and partly by forcing the mouthpiece against the lips by means of the little finger of the left hand. In striving for this C the student may possibly sound B♭ at times, but this note should be avoided, as it is imperfectly in tune and is seldom used as an open note by horn players.

Before making any use of the pistons, the student should extend his acquaintance with the open notes until complete facility is obtained over this series :



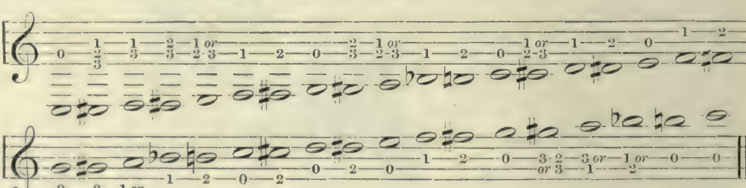
The low C will probably give considerable difficulty in production, and may necessitate a complete change of embouchure, as the lips require to be very loosely arranged. It will be noticed, also, that after practising the higher notes the low ones are more difficult of production, and when the low ones have been practised the high notes become proportionately difficult. This is caused by the great difference of embouchure between the extreme notes of the horn's compass, for which reason the first horn in an orchestra seldom goes below C, first ledger line bass clef, and the second rarely rises above C, third space treble clef. Of course, a solo performer must acquire, by constant practice, equal facility over the whole compass.

It will be remembered that the fundamental note is an octave below the low C already spoken of; but this note is scarcely possible, except on the higher crooks, and even then it is so weak and uncertain as to be practically useless. On the other hand, the notes above the high G, as far as C, second ledger line treble clef, are quite possible, although difficult, and should be diligently practised by the student who aspires to play "first horn." They will be found somewhat easier if practised at first on a lower crook, say, E♭, but may afterwards be played on the F crook. The very greatest pressure required for the top C is obtained in the manner previously described, but in a greater degree.

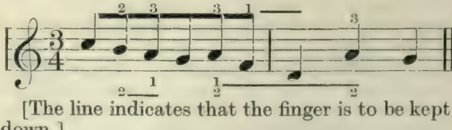
It should be mentioned that the bass clef is sometimes used for the lowest notes, and much confusion has resulted from the practice of the older composers, when so doing, of writing an octave lower than the part is to be played. This senseless custom has now been abandoned, and modern composers intend their music to be played as written, whatever clef they use.

At this stage the ambitious student should procure a book of further studies and exercises. Oscar Franz's "Wald-horn Schule" can be confidently recommended ; it has, however, the disadvantage of being written in German, although this in no wise affects the studies contained therein. The horn parts of standard classical works will likewise afford excellent practice. The symphonies of Mozart and Beethoven, and many others works of about the same period, were written for the horn without valves, and therefore contain almost entirely open notes.

The Valves. It is now time to make use of the valves, by means of which, as has already been explained, a complete chromatic scale can be obtained throughout the whole compass. The fingering for this is shown in the illustration below.



It will be noticed that for certain notes there is a choice between the first and second fingers in combination with the third, either fingering lowering the pitch three semitones. Most horn players seem to prefer the 1 2 fingering, partly because the third finger is less agile than the other two, and partly on account of the greater convenience in such passages as this :



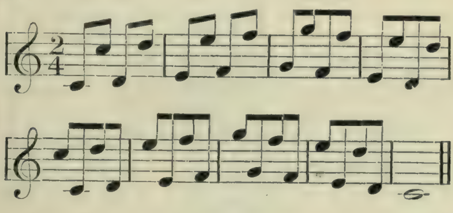
[The line indicates that the finger is to be kept down.]

If the third piston were used here it would be necessary to raise it simultaneously with the depression of another, which might impair the smoothness of the passage, whereas, by using the lower fingering, only one movement at a time is necessary.

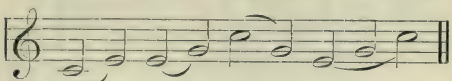
Furthermore, a little consideration will show that many notes have several possible fingerings. The B on the third line may be lowered from the open C by the second piston, or from the D by the third, or from E by the first and third. It is impossible to make any rules for the employment of these additional fingerings, their use being solely a matter of convenience, but an example or two may serve to indicate their usefulness. At the top is shown the ordinary fingering, that given below shows the simplicity attained by the alternative fingering.

The valves are provided with sliding pieces of tube for the purpose of tuning, according to the crook in use; the lower the crook, the more extended must be the slides. The position shown in the illustration is right for the F crook.

The major and minor scales and arpeggi should now be practised in all keys and exercises in the various intervals, a useful, though somewhat difficult one being the leap of an octave, thus:



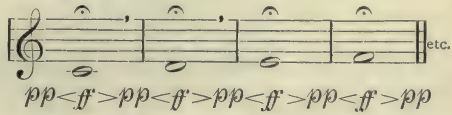
Slurring and Phrasing. A few words will be advisable on the subject of slurring and phrasing. It has been shown that a note was produced by pronouncing the syllable "ta." This has the effect of giving the note an accent, or "attack." But one note may be made to glide into another without any perceptible break by pronouncing (approximately) these sounds:



thus making the vowel-sounds more acute as the passage ascends, and broadening them in a descending passage. It is, of course, possible, and often desirable, to "attack" a note so gently as to entirely avoid an accent. When two notes are slurred together, as in the foregoing example, the second one should be played more lightly than the first, and especially so when the second is the shorter of the two. If the reverse effect were required it would be specially indicated, thus:  implying a *crescendo.*

The student should now endeavour to cultivate a wide range of tone, varying from the beautiful dreamy *pianissimo* to the big "brassy" *fortissimo*, taking care that the air-pressure and embouchure do not alter and so affect the note.

One of our most eminent horn players, before playing at a concert, invariably practises a scale in this manner.



taking breath for each note and holding it as long as possible. It is one of the finest exercises for getting one's lips into good condition.

The Mute. A curious effect is produced on the horn by inserting a suitably-shaped pad or block into the bell of the instrument. This, which is called a *mute*, is indicated in German music by the words "*mit dämpfer*," or in most other countries by "*con sordino*;" or a cross over a note, thus,  is sometimes used instead. Muted horns played *pianissimo* have a curiously faint and far-away sound; played *fortissimo* the effect is not easily described, but it is very different from the open sounds. For isolated stopped notes the horn may be muted with the right hand by bending it over at the knuckles and blocking up the bell.

There is a remarkable want of agreement among theorists as to the precise effect produced by the mute on the pitch of the horn. Before the invention of valves it was customary to fill in the gaps of the harmonic scale "by the insertion of the hand or other obstacle into the bell of the instrument, partially blocking the tube, with the effect of *lowering* the pitch of all the notes a semitone or a tone." On the other hand, another author tells us that "by stopping the bell with a pad the pitch of the instrument is *raised* a semitone." Each of these statements is fully corroborated by other authors. Which is the one to believe? In a sense, both authors are correct. By inserting the hand into the bell the note can be gradually lowered to as much as a whole tone; at the same time, by the use of the mute or hand, it is possible to play a passage a semitone higher than it would sound without this device. The student must remember when playing a passage marked *con sordino*, to make allowance for this alteration of pitch, preferably by keeping the second piston down, when the passage will be lowered to its normal pitch. When a rest of sufficient length occurs in the music, the crook should be removed and the water emptied out of it to prevent any bubbling sound.

TRUMPET, CORNET, AND HORN *concluded*

Group 12
MECHANICAL ENGINEERING
38
MACHINE TOOLS
continued from page 5283

LIGHT PORTABLE MACHINES

Electrically Driven and Pneumatic Portable Machine Tools for Drilling, Tapping, Reaming, Expanding, and Riveting

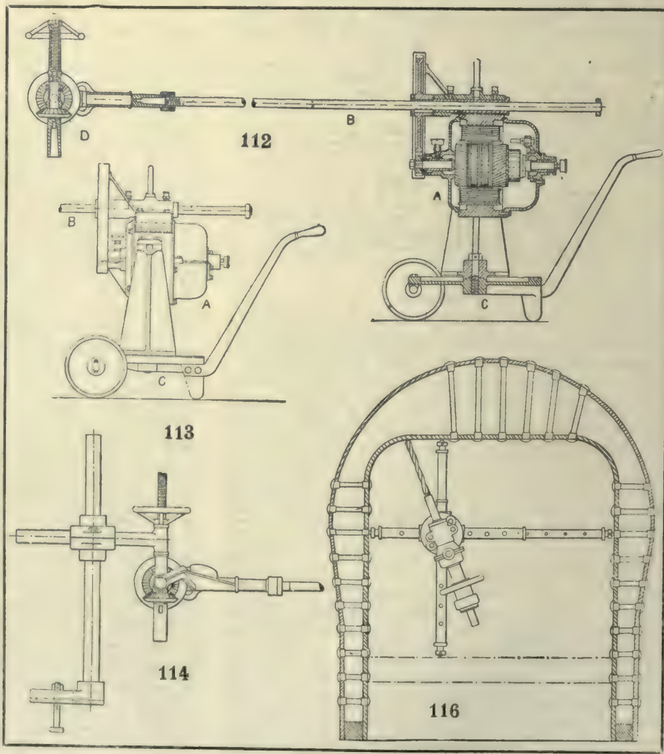
By FRED HORNER

CONTINUING our account of those types of portable machines which are attached to the work, we note the valve-face tools, used for planing-up worn faces when the cylinders are in place. A cast-iron frame is bolted to the cylinder, and it carries two revolving heads, provided with cutters, which rotate as they are slid along in grooves, and so gradually tool the area of the valve-face. For situations where there is considerable freedom, a small portable milling machine with vertical spindle is useful, the spindle being supported in a bearing that slides across a rail bolted above the valve-face. This method also possesses the advantage that by inserting small end mills in the spindle the ports may be trued out neatly and accurately, instead of having to be chipped and filed.

Keyway Cutters. A very valuable class of tool which supplants the chipping and filing method is that for putting key grooves in shafts and wheels. The first kind of machine usually embodies a set of clamps, which are bolted to the shaft, and afford a runway for a bearing supporting a milling cutter, which ploughs out the groove, a drive by handle being usually given. The machine may be carried anywhere, and fastened on a shaft while in place. It is often found necessary in engineers' and other works to add extra pulleys to existing shafting in order to drive new machines laid down, or to suit altered positions. The alternative, then, is either to cut a keyway by hand methods, or to take the shaft down and put it on a slot-drilling machine, which cannot usually be done on account of the trouble and delay to the shop, or to do the job with a portable machine, the last-named method being the quickest and best. In the case of wheels, a portable machine may be occasionally useful; it assumes the form of a bracket-shaped casting holding a reciprocating bar fitted with a slotting tool, which passes into the bore and cuts the keyway in a series of strokes. This machine may also be hand-driven or actuated by a belt or rope wheel.

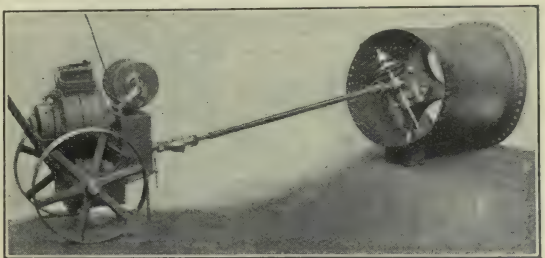
Light Tools. We now arrive at a large group of machines which have developed greatly in recent years, those operated electrically or pneumatically. Both these sources of power are admirably suited to the needs of portable tools, and they are applied in a variety of ways to drive with a rotary or a reciprocating motion. The obvious advantages are that the power can be conveyed to the tools in a very flexible manner, to accommodate any movements or positions, and without such encumbrance as would be found if ropes or belts were used. On outdoor work especially these rope or belt drives are most awkward to produce, because of the difficulty of finding a location from which to drive off, whereas in a shop an overhead countershaft may be attached to the ceiling joists. On the other hand, an electric cable, or a pneumatic hose is simply laid along the ground and carried over obstacles without trouble or regard being paid to angles or to passing around corners.

Before the advent of the electric and pneumatic motors, a certain amount of portable work was effected with steam and hydraulic engines, chiefly for drilling, to save time over ratcheting with a



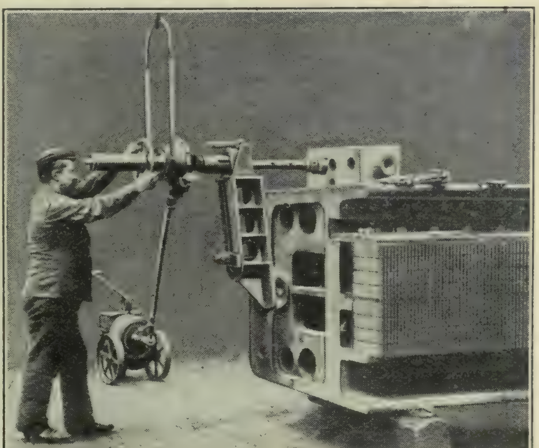
112–114. Portable electric drill 116. Portable drill inside firebox

"John Bull," or drilling pillar, and a ratchet brace [see **103**, page 835], which is a slow method, although convenient where no power is available, as are also the hand-driven drills operated through a handle and bevel gears driving the drill spindle. The steam was, however, an inconvenient source of power, due to the condensation which occurs in the long pipes, and the trouble caused by leakages. Hydraulic power also suffers limitations. Electricity gives no trouble, nor does air, if the pipes are not leaky. The source of power—the dynamo, or the air-compressor —may be placed in any convenient location; in a large works there will be many scores of portable machines all drawing their energy from a central source. Ship and bridge-building yards especially favour the use of these agents, because so much of the work has to be done upon partly erected structures.



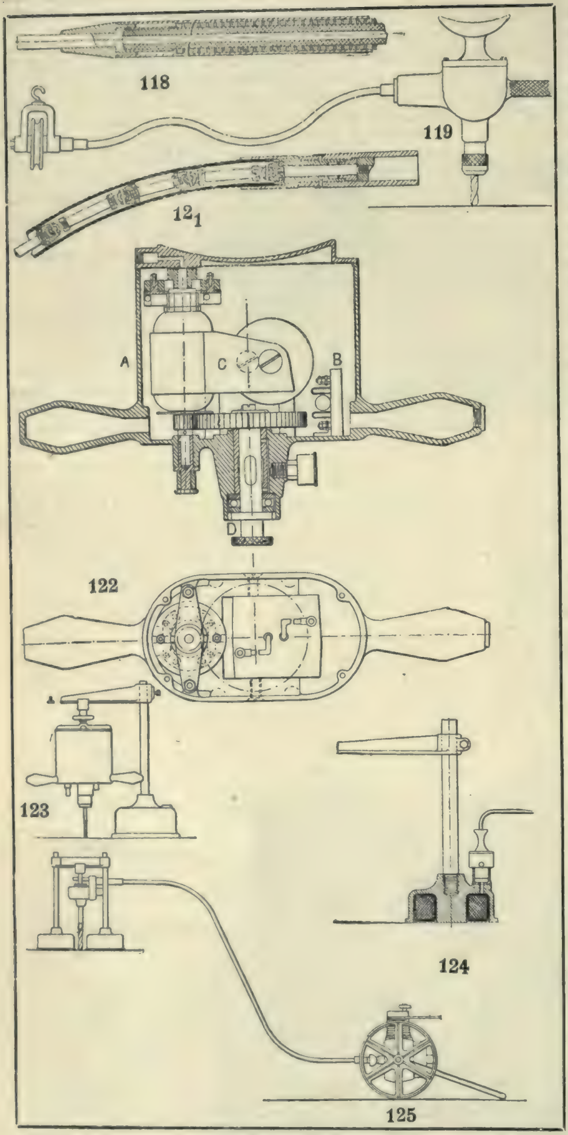
115. PORTABLE ELECTRIC DRILLING OUTFIT

There are two principal methods of driving the light portable tools; the actuating motor is either built into the body of the machine, or it is situated a little distance off, and the movement is transmitted to the tool through the medium of ropes or cords, or by flexible shafts, or both combined. The reason for the adoption of one or the other device is chiefly one of weight; it would be inconvenient and troublesome to keep shifting a heavy motor about over the work, especially if the latter should be placed in difficult situations, and the time occupied in setting and adjusting would be out of all reason. But if the class of operation is so light that the motor and the machine parts can be moved about easily by one or two men, then the flexible shaft can be dispensed with. As we shall see later in this article, some of the lightest tools can be handled with the greatest ease by one man, yet their capacity far exceeds that of the older hand-driven tools. The commonest class of operation done by these light portable tools is drilling, as it was also the first effected by their aid when the early attempts to oust hand-work were made. The scope of the tools has, however, greatly extended, and many operations that were once deemed outside the range of power-driven machines are carried out extensively nowadays.



117. BORING DYNAMO HOUSING WITH PORTABLE MACHINE

Electrically Driven Drill. We shall consider first a class of drilling machine driven from an ordinary shaft, which, nevertheless, allows a great degree of flexibility in the position of the drill. The machine, by Campbell & Isherwood, Bootle, is shown in **112** and **113**, the first being a sectional elevation through the motor and the drill, and the second an external elevation of the motor and its stand. The electric motor, A, is enclosed and a pinion on its shaft drives a spur wheel on a sleeve in bearings above the motor. The sleeve rotates the shaft B, which is free to slide endwise through the sleeve, though driven positively by it at any position through a key fitting in a spline extending down the shaft. The motor, and its frame, including the gears and shaft, may pivot in a vertical direction through the medium of trunnion bearings [see **113**]. These bearings are mounted upon a truck, C, by a circular facing and central pin, which permits the motor and trunnion bearings to turn freely into any position. The universal movements thus obtainable allow the operator to bring the drilling head, D, into any location he may desire, up or down, or sideways. The base, C, is fitted with a couple of trolley wheels, and two handles, as seen, so that it may be wheeled about, and brought into position. The plain feet at the opposite end to the trolley wheels prevent motion when the machine is standing. There is an eyebolt screwed into the top of the frame, by which the whole affair may be slung up in the air, if more convenient than the ground position. The shaft, B, is coupled to the drill head shaft with a taper and union nut, and the motion is transmitted thence to the drill spindle through bevel gears. The spindle can be swivelled to any angle, and the feed is imparted by the hand wheel and screw fitting inside the drill sleeve, the end of the screw having a point centre which thrusts against any convenient projection, or against an arm attached to a pillar, or "John Bull," provided with a foot to bolt to the work [**114**]. A small switch attached to the side of the head, D, enables the operator to start or stop the motor, A, at will, the flexible connecting wires being laid between the two. These machines are made in three sizes, with capacities for holes ranging from 1 in. to 3 in. diameter, the drill speeds varying from 180 down to 60 revolutions per minute. The motor being a series-wound type, the speed of the drill is proportionate to the duty imposed. In a different design, three-speed gears are included with the



PORTABLE MACHINE TOOLS
118 to 121. Flexible shafts for transmitting power **122.** Electric drill **123-125.** Magnetic drilling pillars

motor frame, to afford considerable variations in speeds, for tapping, and other operations besides drilling.

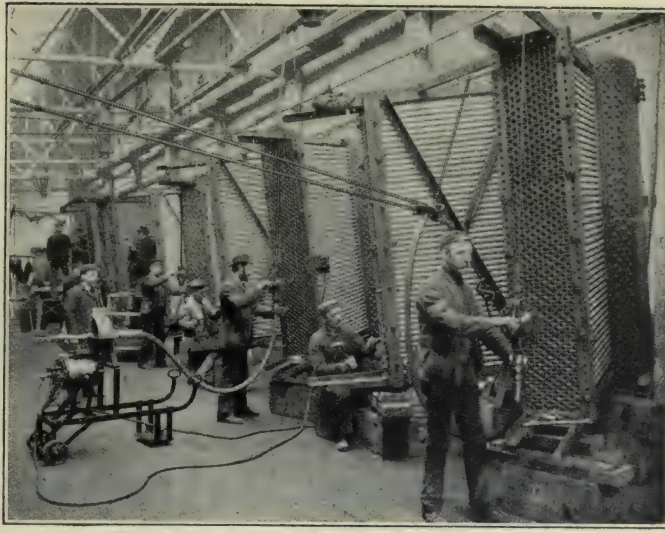
Universal Shaft Drive. In a different class of drive, which is largely adopted, flexibility of connection is obtained by making the shaft with universal joints, having double-pivoted or ball fastenings, which allow the parts of the shaft to assume angular positions. This being the case, there is no need to tilt the driving motor. The differences in distance between the motor and the drill are provided for by fitting one part of the shaft within the other, and making them drive by a sliding key, constituting a telescopic shaft. Figure **115** is a good example of this mode of driving, from the practice of Emil Capitaine & Co., Frankfort-on-Main; the portable motor, seen to the left, mounted on wheels, receives its current from a flexible cable, which is wound around the drum on the top, at the front. A drive is taken from the motor shaft to a socket on the front, into which the end of the universal shaft is fastened. The universal joint at this location drives the telescopic part of the shaft to another joint, which rotates the drill spindle through gears; the spindle is held in a frame that may be secured to the work, in this case a boiler flue, by adjusting screws.

Arrangements are made for giving different speeds by having a set of gears inside the motor frame driving to three different sockets, at various speeds, the end of the universal shaft being inserted in either, as desired. Or if two drills happen to be wanted in use adjacent to each other, a couple of shafts may lead from the sockets and diverge to their respective heads. A device which still further increases the possibilities of drilling is the *distributor*, a small stand having several connections leading out of it for driving universal shafts, the power being put in by another shaft from a motor situated a little way off. When the distributor is laid down on the floor, it operates four or more drills surrounding it, and occupies far less space than that required by the necessary number of separate motors.

A somewhat similar class of rig to that shown in **115** is illustrated in **116**, also a Capitaine device. The drilling head is held to a casting from which four tubes radiate, and carry rods, which are slid into any position and locked with small pins. Screws on the end of the rods tighten the affair inside the work, a fire-box in the example given. The drill spindle, driven from a universal shaft extending into the box, is then turned into various positions to drill the stay holes. The dotted stretcher bar seen near the bottom is necessary only when the drill is pointing vertically.

Boring and Drilling Rig. Another application of the Capitaine machine is that in **117**, which shows a boring rig in operation on the face of a large dynamo housing in the shops of the Allgemeine Electricitäts-Gesellschaft, at Berlin. The drill head is driven, in this case, by a worm gear, enclosed, from a universal telescopic shaft coming up from the portable motor seen on the floor, and is held in a large slotted base piece bolted to the face of the work. As the base and the drill head are too heavy to lift about, a stirrup is attached, and suspended from the overhead crane. The man is in the act of turning the hand wheel that gives the feed to the tool. A boring bar, supported between two bearings, may also be driven in this manner, with a universal shaft. There is a different method of driving used when the electric motor is

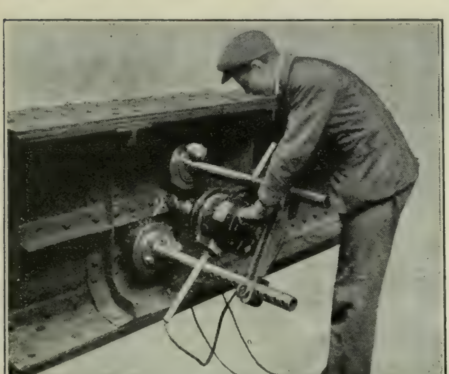
not possible : the universal shaft is worked from a suspended pulley, connected with a hanging rod to a pulley in the ceiling, which allows a good deal of accommodation to follow the varying positions of the drill. The device is, of course, more awkward and cumbersome than the motor drive, and is liable to get in the way of tall work.



120. FLEXIBLE SHAFTS DRIVING TUBE EXPANDERS

The Flexible Shaft Drive. The *flexible* shaft differs from the universal telescopic in being able to bend, due to its peculiar construction. With one end attached to and driven from the motor or other source of power, the free end may be turned into any position which the tool demands. The shaft may be bent round a corner, where one of the straight shafts previously discussed could not be brought into action. The first flexible shaft was the Stow, a type still employed very largely; it consists of a number of steel wires wound in right and left hand directions, and fitting within each other to form a sufficiently strong driving medium ; the outermost layer runs inside a flexible tube formed of coiled wires of square section, and this again is encased in a leather covering. A lubricant is applied to the running portion, either lard oil, or tallow, but not a mineral oil, to enable it to run freely. The action of the wires will be readily understood by taking hold of a spiral spring by its ends, bending it to an angle, and revolving one end, when it will be found that the motion is transmitted around the bend. The reason for multiplying the coils is that a single one would not be able to stand the strain unless it was of excessive thickness, and this would interfere seriously with the flexibility. The ends of the core are attached to a short, plain end, which forms a means of attaching the driving and the driven portions.

Figure **118** shows a section of the end of a shaft



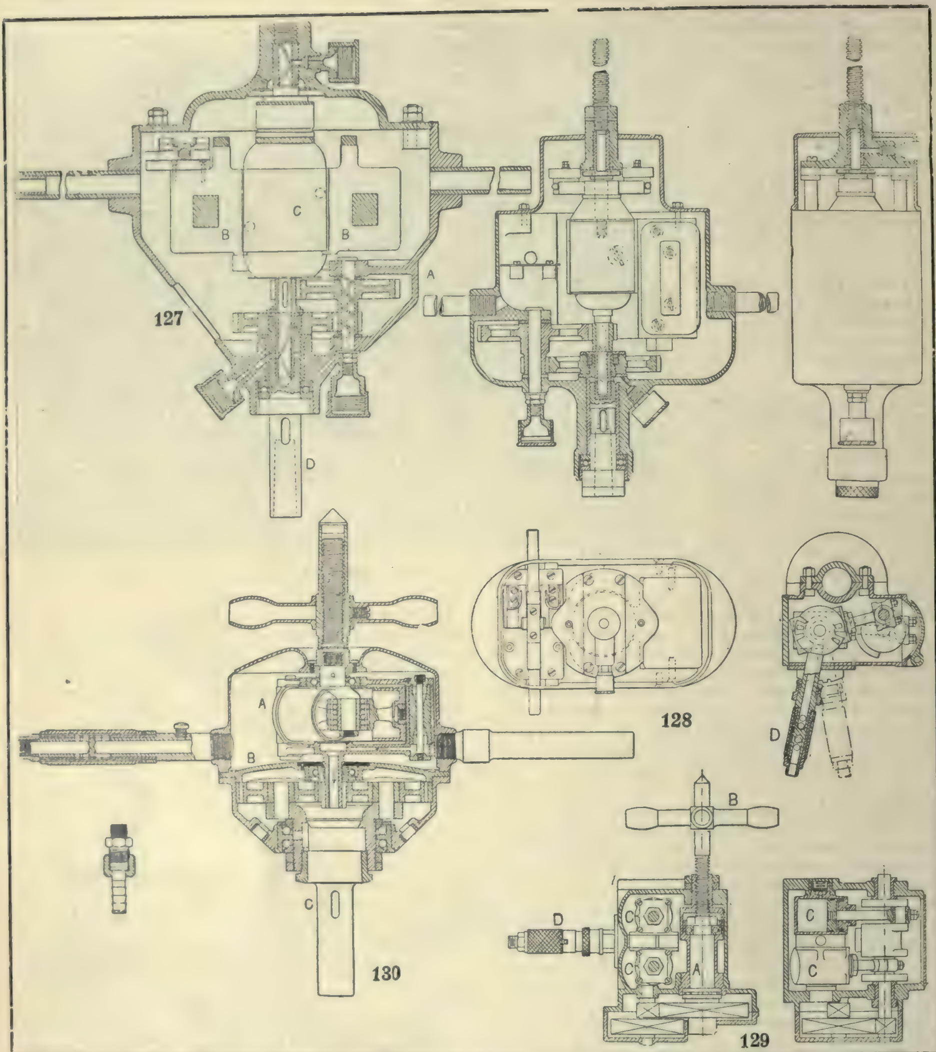
126. ELECTRIC DRILL WITH MAGNETIC POSTS

by Kramos, Ltd., Bath, embodying the central core of wires (indicated by cross-hatching), the outer bearing tube, and the leather casing. The end of the core is fitted to a short piece of shaft projecting through a bearing, the free portion of shaft being available for putting on various styles of fittings. In **119** the shaft end has a rope pulley, with a hook by which it is suspended, while the pulley is driven from a cord actuated from an overhead drive, or from a motor. The other end of the shaft connects to a breast drill, driving the spindle through intermediary bevel gears inside the casing.

An interesting example of the use of flexible shafts is illustrated by **120**, the view being taken in the works of Messrs. Yarrow & Co., Ltd., at Poplar, where the system has been in use for many years. The operation is that of expanding the tubes in water-tube boiler sections, the expanders, of a similar character to those described on page **3104**, being rotated from the shafts through bevel gears, similarly to drills. In the foreground of **120** the shaft is seen to be operated from a rope and pulley, the rope being driven from a countershaft. The second shaft is deriving its power from a portable electric motor (very much like that in **112** and **113**).

It is usually advisable to connect the driving end of a flexible shaft with a universal joint, to prevent risk of too sharp a bend being made, which would put an excessive strain upon the core on the end portion.

The Coates flexible shaft, instead of possessing a central core of wires, has a number of short sockets and studs fitting into each other with ball ends and transverse studs, so that although the drive is positive, angular relations may occur between the units. The core revolves within a spiral casing, which is surrounded with a protective covering; ample lubrication is essential. The Wicksteed shaft, shown in section in **121**, which represents one end and a few joints, is built up of connecting rods with universal joints screwed on the ends to give the required flexibility ; the outer casing is a flexible metallic tube which holds the lubricating oil for the joints to run in. Ball races



127 and 128. Electric drills 129. Two-cylinder pneumatic drill 130. Three-cylinder pneumatic drill

are fitted to the peripheries of the universal joints to reduce the friction and wear on the inside of the casing to a minimum. The end of the shaft has a positive or friction clutch by which connection is effected to the tools. The dimensions range from an outside diameter of casing of $\frac{3}{4}$ in. up to $2\frac{1}{8}$ in., transmitting powers from $\frac{1}{8}$-h.p. up to 3-h.p. They can be made in any length required, as friction is small. Messrs. C. Wicksteed & Co., Kettering, the makers of this shaft, provide a portable electric motor, carried on a trolley, upon which the motor may be revolved. The shaft receives its motion from a second shaft driven at a suitable rate from he motor through friction safety gear.

In addition to the operations of drilling and expanding mentioned, various other tools may be conveniently driven from these flexible shafts, such as taps and reamers, wood-boring tools, and grinding and polishing wheels. The latter is a very useful application for grinding and polishing work which could not be conveniently done on a fixed grinder. The operator simply holds the wheel by means of two projecting handles on the bearings, and moves it about over the work, to smooth down the inequalities, and produce a good surface. The flexible shaft sticking out from one handle does not interfere with the free movements of the wheel to and fro, or into awkward corners.

Direct Driving. The direct-driven tools—that is, those which have the motor built into the body—are very numerous: they possess the great advantage that no moving shafts or ropes are in the way of the work or the attendant, the only connections being cables or pipes, which can be laid along in any manner that happens to be

convenient. The direct-driving method also lessens complication, and there is only the drill or other machine to be carried about, instead of a separate portable motor, with its connecting ropes or shafts.

Electric Drills. The electric drills are either of *hand* or *breast* type, or used with a *pillar*, which supports the machine and takes the thrust of the cutting. The pillar, in addition to holding the machine ready, keeps it at the correct angle to the surface of the work; when gripped in the hands alone, it is not easy to be sure that the drill points quite squarely, though the accuracy or otherwise may be judged near enough by the eye for ordinary work. The hand drills must be provided with projecting handles by which they are controlled easily; **122** gives two views of an electric hand or breast drill (Kramos, Ltd.) of small size, weighing about 15½ lb. and drilling holes up to ⅜ in. It consumes 1·2 amperes at 110 volts, and is worked from a lamp-holder socket, as used for incandescent lighting. The case, A, is cast in aluminium for lightness, together with the two hollow handles, the right-hand one serving as a passage through which the flexible wires are led to the motor, first connecting to a switch, B, operated by the attendant from the outside, to start and stop the drill instantly. The motor, C, is attached with screws inside the case, which fits the outsides of the pole-pieces exactly, as may be seen in the plan view. The armature revolves with its shaft in a bushed lower bearing and an upper stretcher bearing, the latter being necessarily screwed on after the armature has been dropped into place.

As sufficient power would not be afforded by the rotation of the armature, a gain is effected by reduction gears, comprising a pinion on the armature shaft, driving a large spur wheel on the drill spindle, so that the latter revolves at a slower rate. The drills are held in a tapered hole in the spindle; the latter runs in a gun-metal bush, lubricated with a Stauffer type lubricator, and the thrust of drilling is taken against a ring of balls, which greatly reduces the friction. The curved plate at the top end of the case is shaped thus to fit the operator's chest as he leans over and presses the tool down, while grasping the two handles. This plate is screwed on to the case; in the plan view it is shown removed. Another pattern of this machine is constructed to drill holes up to ½ in. diameter. The speeds are arranged to suit high-speed steel drills.

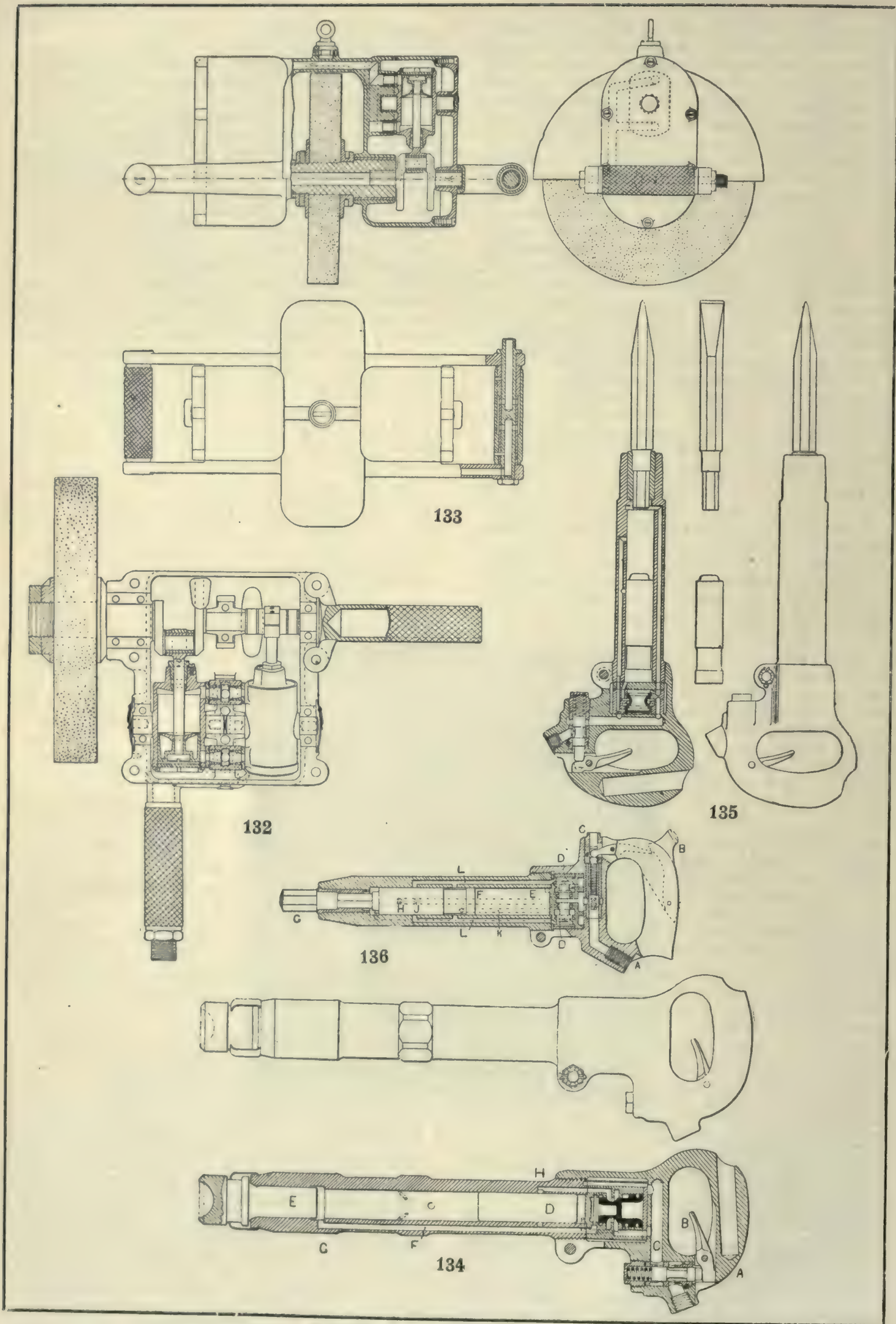
If required for some kinds of drilling, the curved breastplate may be replaced by a plate fitted with a feeding screw, to press against any convenient part of the job, or to be suspended from a pillar and arm [**123**]. The arm is of tee-section, and holds a hooked extension of the drill screw, so that the machine hangs steadily when not at work, instead of falling down like the ordinary types with a point centre thrusting against the underside of the arm.

131. PNEUMATIC DRILL AND MAGNETIC PILLAR WORKING ON A BATTLESHIP

Magnetic Pillar. The pillar shown in this illustration is not of the usual style, secured with bolts to the work, but is of the *electro-magnetic* type, which clings to the iron or steel work by the action of a magnet base. The advantages of this device are obvious, for it not only saves a large amount of time otherwise occupied by bolting down the foot, but enables the latter to be secured to broad, flat faces where bolts or clamps could not be fixed, unless of unusual or very long types. The magnetic base, therefore, fills a particularly useful position in ship and girder yards, where plates of broad area are common. Figure **124** (Kramos, Ltd.) gives a sectional view of the base, which is hollowed out to receive the energising solenoid, the wires being represented by cross-hatching. The current is led through the flexible wires to a plug which is dropped into the holder on the top of the foot, which thus becomes strongly magnetised, and clings firmly to the work. It is released immediately the plug is removed from the holder. The arm on the round pillar may, of course, be moved around, or up and down into any desired position, and clamped by the set-screw which squeezes in the split lug.

Two pillars may be employed for heavy service, as in **125**, where the drill is suspended from an arm spanning between them; the drill in this example is driven from a flexible shaft, operated by a portable motor, of the class mentioned previously. A photograph showing the application of an electric drill with duplex magnetic pillars, by the Consolidated Pneumatic Tool Co., Ltd., London, is given in **126**, the drill being put through a girder of a bridge, while the magnetic feet adhere to the vertical face of the plate. The pillars are made of tubes, for the sake of lightness, and a number of holes are drilled to receive pins, which take the thrust of the spanning arm against which the drill presses.

Heavy Electric Drill. A heavier electric Kramos drill, which is suitable for holes up to 1¼ in. and weighs about 60 lb., is shown in section by **127**. The aluminium casing, A, of approximately triangular form, holds the heavy pole-pieces, B B, between which the armature, C, rotates. The drill spindle, D, is driven through a set of back gears, affording a considerable power gain, with corresponding speed reduction. It will be noted that the armature shaft is in the same plane as the drill spindle, and the bottom end of the former runs in a hole in the latter without interfering with the last spur gear attached to the outside of the spindle. The details of the bearings, with a ball thrust to the spindle, and the lubricating devices may be seen clearly. The current is taken through the left-hand handle, formed of pipe screwed into the casing, to the starting switch. The handles serve a double purpose—that of providing a means of lifting the tool about, and also of preventing



PORTABLE PNEUMATIC TOOLS

132 and 133. Pneumatic grinders 134. Long-stroke pneumatic riveting hammer
135 and 136. Pneumatic chipping hammers

the case from rotating during use, because they catch against the drilling pillar. The thrust of the drill is produced by an ordinary hand wheel and screw device, let into the top of the case, though not shown. In some kinds of work, such as counter-sinking, which can be drilled with the machine standing vertically, the pillar may be dispensed with and the tool simply steadied by the hands, while its weight is sufficient to give the drill its feed.

Figure **128** shows another drill by Messrs. Kramos, which, though of different shape, embodies somewhat similar construction and mode of driving with gears. It contains many interesting details that may be studied. The feed screw is shown let into the top. The switch is operated by pushing one or other of the plungers seen in the plan view, the effect being to slide the contact piece in between the two springy pole strips, or away from them. A safety fuse is provided with these drills, which blows out should an excessive amount of current pass, and so saves the motor from damage. Owing to the high speed of the working parts efficient lubrication is essential, and particular attention is paid to this point.

137. PNEUMATIC CHIPPING HAMMER FETTLING CASTINGS

Pneumatic Tools. The pneumatic tools constitute a large proportion of the light classes employed in works; they come into rivalry with the electric types to a certain extent, while in some cases they do work which electricity is unable to effect—that is, those which employ hammering, or reciprocating movements. One reason for the frequent adoption of electric tools is that so many firms have current laid on throughout their works, which is readily applicable to driving portable tools, and a pneumatic plant may not be installed. When, however, the latter is put in, full advantage is taken, and tools of widely varied character are brought into service. The power is derived from air passed from an air compressor, at pressures which are varied to suit the work, but usually at 80 lb. per square inch; a receiver stores a quantity as a reserve for the tools to draw from. Portable compressing plants are used on outdoor work, where it may be desirable to shift the compressor, etc., about to different situations. Hose pipes lead from the receiver to the tools, the armoured type of hose, protected with coiled wire, being preferable on account of the rough usage and dragging about which it has to endure. A coupling unites the hose to the pneumatic tool, and means of shutting off the supply of air are provided, as we shall see later.

138. PNEUMATIC CAULKING TOOL IN OPERATION

Pneumatic Drill. The production of a rotary motion by compressed air is effected in the majority of cases by cylinders and reciprocating pistons, like those of steam engines. Figure **129** gives three views of a reversible drill (made by the Howard Pneumatic Engineering Co., Ltd., Eastbourne), which is of rather simple construction. The casing, cast in aluminium, holds the drill spindle, A, inside a sleeve, from which the thrust is taken by ball races and transmitted direct to the feed screw, B. The rotation of the spindle is produced from a pair of little oscillating cylinders, C C, which are mounted on trunnions, and which, as they oscillate, cover and uncover the air passages in a block lying between them, so admitting and exhausting air alternately to the opposite sides of the pistons. The handle, D, serves to steady the machine, and also to turn on the air, by partly twisting the knurled outer sleeve, which lets the air pass through holes and so from the supply pipe screwed on the handle end, to the cylinders. This handle is used as well to reverse the direction of motion of the engines. It is screwed into the valve disc between the cylinders, and has a spring collar on its body which engages in slots cut in a quadrant outside the casing. By swivelling D around to the position indicated by the dotted lines in the plan the relations of the inlet and exhaust passages are altered, and so the engine runs backwards, a useful provision for tapping and tube expanding.

The piston rods of the two cylinders drive to crankpins at right angles on a balanced crankshaft, on the end of which there is a spur pinion meshing with a wheel which drives another pinion engaging with a large spur wheel on the drill spindle. The crankshaft rotates from ten to fourteen times as fast as the spindle. By taking off the cover at the bottom, removing the pinion on the crankshaft, and its companion wheel, and substituting others of different ratios, varying rates of speed may be obtained to suit the operations done. A reducing gear is also fitted as an extra to the front of the drills, by which a slow and very powerful motion is obtained for heavy tapping. Another useful attachment is the extension gear, consisting of a small auxiliary spindle with its feed screw standing out from the casing of the machine in a manner that enables holes to be drilled in very close situations, such as in corners, or close up to plates, which would prevent the main spindle from being brought into action, on account of the bulkiness of the casing.

The Howard Company have a little machine designed for drilling metal and wood with drills and bits of small diameter, which drives by means of a fan wheel with vanes at a very high speed.

The Boyer drill [**130**] (Consolidated Pneumatic Tool Co., Ltd.) is a rather unique design, possessing three cylinders, A, which revolve around a common pin-crank that is fixed into the top of the cover. A diaphragm, B, separates an upper chamber containing the cylinders from a lower one holding the toothed driving gears. Air is admitted to the top chamber through the throttle handle on the left, and causes the single-acting cylinders, through the medium of their pistons, to revolve a disc ending in a hollow shaft that passes centrally through the diaphragm, B, with a leather washer surrounding the hole. No air can therefore get out of the upper chamber, except through the cylinders and along an

exhaust passage communicating with this hollow shaft, whence it escapes through two holes on the sloping undersides of the case. A small pinion is fastened on the end of the hollow shaft, and engages with two spur gears meshing with an internal ring of teeth inside the case. Each wheel fits on a pin forming part of a sleeve or socket holding the drill spindle, C, and as the wheels travel rapidly round the ring of teeth they carry the sleeve with them, and so rotate the drill. Ball bearings are fitted to relieve the friction. A drawing of a four-cylinder reversible drill by the same firm was given on page 1803, to which reference may be made.

In **131** we have an example showing the application of a pneumatic drill, in conjunction with a magnetic stand, drilling the deck-plates of a battleship. This illustration is from the practice of the Pneumatic Engineering Appliances Co., Ltd., London, the drill being one of their Thor types with four cylinders.

Pneumatic Grinders. Grinding machines, driven pneumatically, are coming into use to a considerable extent for finishing and trimming surfaces which cannot be handled on ordinary grinders in the shops. Figure **132** shows the Whitelaw grinder (Consolidated Pneumatic Tool Co., Ltd.). The frame, of flattened form, with rounding ends, carries two oscillating cylinders on trunnions, with a valve set between the two. The piston rods drive the pins of the crank, on the end of which is mounted a grinding wheel. The two knurled handles seen are for holding the machine to its work, the lowermost one taking the hose, and shutting off the air or turning it on, with a mechanism similar to types described before.

Figure **133** illustrates another Whitelaw grinder by the same firm, for a 10-in. wheel, which has the two handles placed in a better position for even control; they are round knurled sleeves set in extensions of the frame, one of them being a valve. Two oscillating cylinders on each side of the wheel drive it (one cylinder only is seen in section). An eyelet in the top of the frame is useful for suspending the latter over the work while the attendant guides it about. If a very flat surface has to be ground, the wheel may be controlled by fitting guide strips to surround it and to rest on the work, so that as the machine is slid over the wheel must take an equal depth of cut everywhere, and move in a true plane. Some of the largest machines are designed for grinding armour-plate after it has been put into place.

Reciprocating Pneumatic Tools. The rotative types of pneumatic motors all have their rivals in the electric motors, but there is another field in which they hold their own—in the production of reciprocating motion, for striking blows, an operation that cannot be effected by electricity except in a very roundabout and clumsy manner. The mode of action is to drive a sliding piston alternately to and fro, causing it to strike an extension of the tool, and so deliver a rapid series of sharp blows, from 600 to 2,000 per minute. The operator holds the tool and keeps it up to its work, air being led from the supply through a flexible hose.

Hammers for chipping, caulking, and riveting do not differ from each other in the essential action, but as the last-named operation demands very heavy blows in order to close up the rivet tails quickly, what is termed a *long-stroke* hammer is used, constructed with a much longer barrel than the chipping hammers, in order to give the piston a longer stroke. The air pressure is also usually greater, averaging 100 lb. per square inch.

Pneumatic Hammers. A sectional drawing of long-stroke hammer has been given on page 1803, of the Boyer type. In **134** the Tierney riveting hammer (the Globe Pneumatic Engineering Co., Ltd., London) is illustrated in outside and sectional views. The air is led in through the screwed hole at the bottom of the handle A, and is admitted at will by the operator when he clasps the lever B, which has the effect of opening the spring-closed valve and passing the air up the passage C, from which it gets through holes and past the valve (shown black) behind the piston D, driving the latter forward until the hole H is uncovered, which admits air at full pressure and drives D with great force against snap E. The automatic action of the valve (shown black for clearness) then shuts off the air behind, and admits a supply in front of the piston, through the long passage F and hole G, driving D backwards in readiness for another blow. The exhaust takes place through H.

A Tierney chipping hammer of shorter stroke is illustrated in **135** in external and sectional elevations, with a chisel in position, and also shown separately. The shank fits by a part round and part octagonal portion, to prevent its rotating in the bushing that is fixed in the nose of the tool. The action of the hammer is similar to that in **134**, but a modification is made in the position of the air-holes on the underside, because of the greater length of the piston (seen separately).

A duplex-valve hammer made by the Pneumatic Engineering Appliances Co., Ltd., London, shown in **136**. is noticeable on account of the double valves, which give a better action to the tool at high speeds. The air is taken in by a pipe screwed into the hole at the bottom of A, and is controlled by the thumb lever B, which operates the spring valve inside C, letting the air rush against the ends of the circular valves DD, and force them apart, so that they uncover small ports communicating with the cylinder E, and admit air behind the piston F, driving it against the end of the chisel, or caulking tool G. When the piston is in the position drawn, it has covered up two holes connected with passages H and J, and live air is admitted through the passage K, and around the recess on the piston into passages L, which cause the air to get behind the valves and drive them inwards, allowing the air behind the piston to exhaust through a hole in the cylinder end and out through other holes in the handle to the atmosphere. At the same time air is passed through small holes in the valves D, along a passage, and in front of the piston, where the escape drives the piston backwards.

Figure **137** shows one of these hammers in operation, the work being that of fettling castings; **138** illustrates the mode of application of a caulking tool on boiler seams, the example being a tool by R. G. Ross & Son, Glasgow. Beading, or hammering over the ends of boiler tubes, is another operation effected by pneumatic tools. There are also pneumatic sand rammers for moulders.

MACHINE TOOLS *concluded; followed by* MACHINES AND APPLIANCES

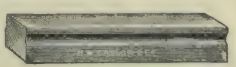
LOCKING-UP THE PAGES	Group 19 PRINTING 4
Placing the Pages in Chases and Formes. Schemes of Imposition. Sizes of Paper. Arranging Margins. The Work of the Reader	Continued from page 5253

LOCKING-UP THE PAGES

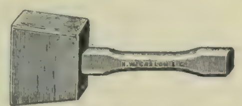
By W. S. MURPHY

WHEN the type has been made up into pages and tied ever so carefully, it is not by any means ready for printing. The machine man would not take it off our hands in that condition. Slide the type off your galley on to the large table with the smooth iron top, designated the stone. The pages lie in a row—one, two, three, four. Supposing the pages are to be printed one by one, and on one side of the paper only, the job is easy.

Placing the Pages into the Chase. You get an iron frame called a *chase*, from the chase-rack, and lay it over page 1. If possible, the type should be protected from the iron side of the chase, and the chase is therefore bigger than the page. A piece of metal or wooden furniture exactly the same length as the breadth of the page is laid between the top and the chase, and a similar piece a little longer than the page is laid along the side. Now open one of the drawers hung under the table, and find a store of wooden wedges, of many sizes, straight on the one side and slanted on the other. These are *sidesticks* and *footsticks*. Select one the length of the bottom of the page, and another for the side, and set them close to the type, making sure that they will cover the whole of the type, and yet be free of each other. Take the cord off the page, and press the sticks close on it. Open another of the table drawers, and there are little wedges of wood called *quoins* varying in breadth from a mere splinter to 1½ in.



19. PLANER



20. MALLET

21. SHOOTING-STICK

Planer, Mallet, and Shooting-stick. In the same drawer lie a heavy, flat slab of wood, a short-handled wooden mallet, and a round tool with wedge point—these are *planer* [19], *mallet* [20], and *shooting-stick* [21]. Wedge in quoins of suitable size between the footstick and sidestick, and the inside of the iron chase, fixing them with finger and thumb. Take the planer in your left hand and let it rest lightly and evenly on the face of the page, gently tapping it down with the mallet in your right. This makes the type level. With shooting-stick and mallet drive home the quoins, plane the type level again, and the page is locked up.

A few fancy books and ornamental pamphlets are printed page by page, but the mass of printing is done quite differently. From the foregoing, however, the student will learn the rudiments of *locking-up*. The page of type, if it has been properly set and firmly locked up, has become a rigid solid, capable of standing the pressure and pull of the printing press or machine.

As we have said, books are not printed page by page; sometimes 128 pages are printed at one time on a single sheet. Here we come to one of the most difficult lessons the young printer has to learn.

Sizes of Sheets for Printing. On opening a book, the first thing the reader observes is the fact that page 2 is printed on the back of page 1, page 4 on the back of page 3, and so on. Nothing seems easier than just to print one side of a sheet with the even number pages, and another with the odd number pages. This would be a feasible plan if all the leaves of books were cut separate, and then bound together leaf by leaf. But books are not made that way. Four at least, should be on one sheet. Fold a sheet and you have two leaves, or folio; folded again it is four leaves, or quarto; folded again, eight leaves, or octavo. A sheet of folio has four pages, a sheet of quarto eight, octavo sixteen, and so on. Most of the old books are folios, because the early printing presses could hold no more than two pages at a time. Shakespeare's plays, for example, were printed folio. The beginner is apt to take those terms as denoting sizes, but that is an error. Folio is simply the half of any size of sheet, whether small post or double demy; quarto is the fourth, octavo the eighth, 16mo the sixteenth, and up to any fraction. We give on this page two tables, the one showing the sizes of papers commonly used, and the other the proportions of the divisions expressed in inches.

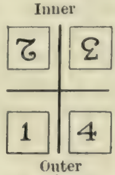
STANDARD SIZES OF WRITING AND PRINTING PAPERS.

	Inches.		Inches.
Foolscap	13¼ by 16½	Double Crown ..	20 by 30
Post	15¼ ,, 19	Double Large Post	21 ,, 33
Large Post ..	16½ ,, 21	Imperial	22 ,, 30
Demy	17½ ,, 22½	Double Demy ..	22½ ,, 35
Medium	18½ ,, 23½	Double Royal ..	25½ ,, 40
Royal	20 ,, 25	Quad Crown ..	30 ,, 40
Super Royal ..	20½ ,, 27½	Quad Demy ..	35 ,, 45
Double Foolscap	17 ,, 27		

SUBDIVISIONS OF PAPER.

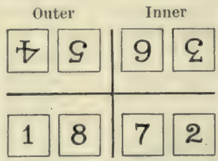
——	Folio.	Quarto.	Octavo.	16mo.
Post	15¼ by 9½	9½ by 7⅝	7⅝ by 4¾	4¾ by 3$\frac{13}{16}$
Large Post	16½ ,, 10½	10½ ,, 8¼	8¼ ,, 5¼	5¼ .. 4½
Crown	15 ,, 10	10 ,, 7½	7½ ,, 5	5 ,, 3¾
Demy	17½ ,, 11¼	11¼ ,, 8¾	8¾ ,, 5⅝	5⅝ ,, 4⅜
Royal	20 ,, 12½	12½ ,, 10	10 ,, 6¼	6¼ ,, 5
Double Foolscap ..	17 ,, 13½	13½ ,, 8½	8½ ,, 6¾	6¾ ,, 4½
,, Crown	20 ,, 15	15 ,, 10	10 ,, 7½	7½ ,, 5
,, Demy	22½ ,, 17½	17½ ,, 11¼	11¼ ,, 8¾	8¾ ,, 5⅝
,, Royal	25 ,, 20	20 ,, 12½	12½ ,, 10	10 ,, 6¼

Placing the Pages. *Imposition* means the placing of things in a definite position, or putting one thing in the place of another; both meanings describe the printer's method of placing his pages. For, it is to be noted, the sheet has to be printed on both sides, and the pages are made up in two divisions, the one called the outer forme, the other the inner. The pages of the outer forme are put in position, and the pages of the inner forme take their places.



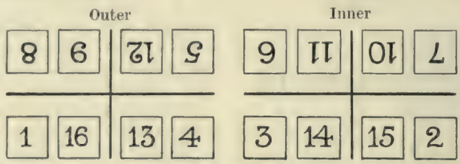
22. SHEET FOLIO

We will begin by imposing the formes of folio [22]. Fold a sheet of paper, and number the pages 1, 2, 3, 4; 1 and 4 are on the same side of the sheet; 1 always begins the outer forme; therefore, 1 and 4 are to be placed together, and make up this forme. Page 1, or the lowest number in every outer forme, stands at the left-hand corner of the scheme. With exceptions to be specially noted, the highest number of the sheet stands next to page 1. In this case it is page 4. Pages 2 and 3 stand together, of course, but it is not enough to say so. The inner forme is the reverse of the outer, and instead of 1 and 4, the order runs 3 and 2.

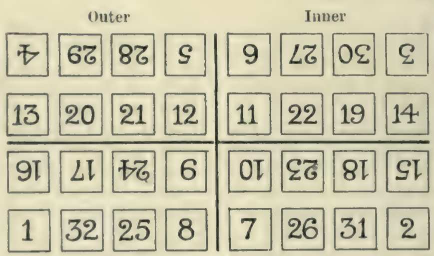


23. SHEET QUARTO

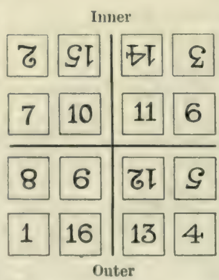
How to Impose the Folio. A good way of finding out schemes of imposition of a complex kind is to number the pages on the sheet, and lay it on the imposing table. The sheet is numbered on both sides; the numbers on the under side of the sheet show the position of the corresponding pages. Our folio sheet affords a simple example. Laid on its back, its pages 1 and 4 lie next the table; turned over sideways, page 3 lies on the place of page 1, and 2 on 4. No matter how complex the problem, this plan always yields accurate results. Another method adopted by beginners who have not mastered the principles of imposition is to take a sheet double the size of that which is being imposed, or twice the number of leaves, and write the numbers on alternate pages, except at the centre, making all the numbers appear on one side of the paper. Turn the figures down on the table; the sheet presents a perfect picture of both the outer and the inner formes. Lift it up again, fold it across, and note how 1 falls on 2, 3 on 4, 5 on 6, 7 on 8.



24. SHEET OCTAVO



25. SHEET SIXTEENS



26. HALF-SHEET SIXTEENS

The quarto sheet offers no difficulty. Have both formes in your eye, as shown in 23. The outer circle, taking both formes, is 1, 2, 3, 4, and the inner is 8, 7, 6, 5.

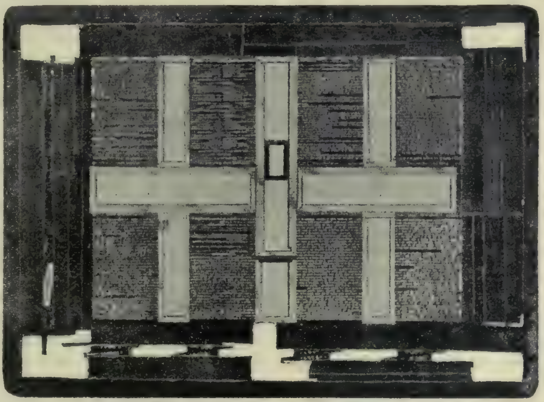
Octavo seems to begin complexity in imposition; but if it is kept in mind that this sheet is four times folio, and the same method applied, the scheme will build itself by natural sequence [24], and similarly with the larger sheets [25 and 26].

Irregular Sizes. The above form the ground-work of imposition. Irregular sizes of sheets, such as 12mo, 18mo, and 24mo, can readily be mastered by application of the methods described and practical experience. To a very great extent, those odd schemes were rendered necessary by the conservatism of the paper-makers, who kept to the old sizes and forms of paper, and the progressive spirit in the printing trade. That opposition has completely disappeared. Paper-makers supply sheets by the roll, measured by the yard, of any breadth desired. The old sizes are rapidly going out of use; off-cuts that make waste of good paper are becoming needless, and intricate foldings, perplexing to the bookbinder, ceasing to trouble.

Arranging for Margins. Having laid our pages our duty is not done. The outer forme of this sheet of octavo has to be locked up. On the chase-rack we find a chase of the proper size, with cross-bars. These are wrought-iron bars fixed in the chase, dividing the interior into four. The pages lie within the divisions, two and two, the heads touching the longer cross-bar. Every page has a fore-edge or front margin, a tail or bottom margin, and a head and a back margin. Provision for the four margins has to be made in due measure. Say that the size of paper gives an inch of margin all round the page. If an equal margin is to be made all round, twelve ems of pica between the sides and heads of the pages would answer. But imposing is not so simple as that. The bookbinder has to be considered, and artistic taste has also something to ask. The outer margin of a page should be wider than the back, and in binding a book the fore-side is often cut. The bottom of the page, being solid, demands a larger margin than the head, which shows white paper between the solid type and the page number, heading, etc. The rule-of-thumb method is to measure with the paper. Having placed

the pages in position, fold the paper to page size. Lay the paper across page 1, and rest it on the edge of page 16. Let the paper overlap the outside of page 1 by as much as you wish the fore-end margin to exceed the back margin, and put furniture into the gap between the two. Open the paper, and you will find, by laying it across both pages together, that the margin on both sides is equal. The space between pages 16 and 13 represents two fore-end margins. To find out this, lay the paper, which is now quarto, against the side of page 13, extending across pages 16 and 1, and make the gap between pages 13 and 16 so that the paper just runs along the outer edge of page 1. These measurements afford the gauges for the rest of the forme. By a similar method, the space between the heads is determined. As we have hinted, however, the more sensible and quicker method is to divide up the margins into a given number of points, or pica ems, and proceed to lay them in, without further trouble.

How to Avoid Mistakes. In the hurry of making up pages and formes, a number of mistakes occur. One page may be a line short, or another a line too long; the furniture between the pages may be of wrong lengths, or miscounted in breadth. To detect all such errors before locking up, the compositor should be provided with a points gauge or a measuring scale. Either of these tools helps in the making up, too. Here is another advantage of the points system of type measurement. When the compositor knows that 36 lines of long primer equals 30 lines of pica, and so on, he can go through with the work of clothing his formes much more confidently and swiftly. Furniture along the sides of pages should be two ems longer than the page, to prevent any possibility of the type slipping out; but the furniture at the heads should always be exactly the measure of the line. This makes a solid forme, and obviates the danger of the side furniture being jammed against the head furniture in the locking up.



27. A LOCKED-UP FORME
(H. W. Caslon & Co.)

The Forme as "Locked Up." Place the sidesticks and footsticks as before directed, and then take the cords off the pages, winding them into hanks at the same time. If possible, a chase should always fit the forme; but if not, the space between the iron frame and the "sticks" should be carefully filled in with good wood furniture or worn metal furniture, till it comes to within the breadth of fair-sized quoins. The quoins having been pressed in, apply the planer to the whole surface of the forme, page by page, and then lock up. Again plane with mallet and planer, this time firmly, and the forme is ready to lift. If the type has been properly set, and the forme firmly locked up, the whole ought to lift solid as a board. During the past 20 years, patent metal quoins, formerly disliked as innovatious, have gradually gained wide acceptance in the trade. As shown in our illustration of a locked-up forme [27] these quoins are wedge-shaped pieces of metal, grooved so as to fit into each other, and toothed on the inner edges for the pinions of the screw-key. Using these we can surround the type with plain furniture, and by opposing the wedges to each other, by means of the key, lock up the forme.

Sheet Signatures. For the purpose of distinguishing one sheet of a book from another, the practice of putting a letter at the foot of the first page of the outer forme was early adopted. By this sign the compositor, the machine man, and bookbinder can tell at a glance what sheet they are working with, and whether or not the pages are numbered correctly. A copy of the table given on the next page is often hung at the side of the imposing-stone.

The Reader. If the compositor always read his copy carefully, always picked up the right letter, always spelt correctly, punctuated faultlessly, read over each line before justifying, and were constantly alert and watchful, he would commit no errors, and, incidentally, be more than human. No man is uniformly in the best of health; the hand momentarily weakens, the attention falters, personal worries interrupt the thought concentrated on the work, and the errors slip past. In the printing world the errors are corrected by the proof-reader.

According to the best practice, a *proof-reader* is a compositor who, because he has produced work comparatively free from errors, and given evidence of self-education and interest in his craft, has been promoted. He sits in a room adjacent to the composing-room, or perhaps his place is on the same floor, and simply partitioned off by wood and glass. When the galley has been proofed on the galley-press, the copy is collected from the compositors, and the proof and copy carried to the reader. Beside the reader is his *copy-holder*, usually a boy, whose duty it is to read out the copy, while the reader scans the proof. The boy should have an aptitude for reading handwriting, and be easily trained to read clearly and correctly. As he reads along

No. of sheet.	Sig.	Numbers of First Pages.						
		Folio	4to.	8vo.	12mo.	16mo.	18mo.	24mo.
1	B	1	1	1	1	1	1	1
2	C	5	9	17	25	33	37	49
3	D	9	17	33	49	65	73	97
4	E	13	25	49	73	97	109	145
5	F	17	33	65	97	129	145	193
6	G	21	41	81	121	161	181	241
7	H	25	49	97	145	193	217	289
8	I	29	57	113	169	225	253	337
9	K	33	65	129	193	257	289	385
10	L	37	73	145	217	289	325	433
11	M	41	81	161	241	321	361	481
12	N	45	89	177	265	353	397	529
13	O	49	97	193	289	385	433	577
14	P	53	105	209	313	417	469	625
15	Q	57	113	225	337	449	505	673
16	R	61	121	241	361	481	541	721
17	S	65	129	257	385	513	577	769
18	T	69	137	273	409	545	613	817
19	U	73	145	289	433	577	649	865
20	X	77	153	305	457	609	685	913
21	Y	81	161	321	481	641	721	961
22	Z	85	169	337	505	673	757	1009

the lines, the reader sees a turned letter, a letter "l" for a "t," and words variously misspelt, punctuation showing that the compositor has missed the sense of a passage, and swiftly marks the corrections on the margin of the proof. Listening carefully, he hears the boy say "traders" where the proof has it "leaders," and the general sense shows that the lad is right; the wrong word is struck out, and the right one written on the margin. By turning to page 4193, the student will find an example of the reader's practice, giving in full the signs of correction and the best methods of marking proofs.

Before sending out the proof, the reader should go over it a second time; he will thus be able to give undivided attention to the spacing and punctuation.

Office Style and "New" Spelling. Considering the number of readers employed in the printing trade, the vacancies offered to the youth ambitious of attaining the position are not numerous. Not that the changes are few. The compositor who is alert and ready finds his opportunity. But there is one factor which, small though it may seem, is very important. Every printing establishment has its own "style." In one place, the readers are instructed to punctuate widely, leave out as many commas as possible, where the sense of a passage appears clear without them. In another office the practice may be the very reverse. Similarly, the use of italics, the style of naming books, magazines, ships, and public institutions, capitals, placing the number of the date before or after the name of the month, and many other details are determined principally by that mysterious power called office tradition.

The English language is always changing in form. Though neither President Roosevelt nor the "Phonetikist" enthusiasts on this side of the Atlantic altered by one iota the spelling of the day, the language does change, both in pronunciation and spelling, by gradual degrees. A notable instance of change in spelling effected within twenty years is the almost universal substitution of "s" for "z" in such words as signify the endowment of a man or thing with a particular quality, as: Civilise, deodorise, mesmerise, and so on. The process is constantly going on, and the reader who would hold his place must keep himself informed on the subject.

Difficult Proof-reading. Reading revise proofs, proofs of author's corrections, and machine proofs are among the higher duties of the reader. The most experienced and skilful of the staff is entrusted with that work, and seldom has any other duty. Such a man performs a highly important function; he is president over the birth of many books, and he ought to possess, besides a thorough mastery of the details of his craft, wide, general knowledge, and a keen appreciation of English words.

Though the reader's chief tool is a well-stored and highly cultivated brain, he should be provided with aids in the shape of a small but select reference library. A good standard etymological dictionary, a classical dictionary, a dictionary of phrase and fable, Roget's "Thesaurus," a Bible, and an up-to-date stock of the more important year books and almanacs make a reasonable equipment. In addition, if the establishment is a large one, there ought to be a reference library readily accessible to the whole reading staff, stocked with the great compilations of authority, such as the "New English Dictionary," "Encyclopædia Britannica," works on technology, and dictionaries of the classical and leading modern languages.

The News Reader. The efficient reader is alert of eye and deft of hand, possessed of a good stock of general information, and fully acquainted with the forms of words, but the news reader's quickness and knowledge are taxed to a specially high degree. He must keep himself in touch with current affairs in politics, society, and life, know the names and politics of political leaders and members of Parliament; the topics of the hour, and the catch phrases of the moment. For lack of such a reader, the slips of the Parliamentary correspondent's pen have appeared in cold print, to the dismay of everybody concerned.

The news reader seldom has time to read matter twice; and sometimes he has to read the bare type. This means that he has to be quick, ready, able to detect not only errors in composing but all other errors at one reading. Very numerous are the traps into which the newspaper compositors may fall, and the reader has always to pull him up. Headlines may become mixed, the bottom or top line of a column may fall and be misplaced, and a hundred other accidents may happen, each one, perhaps, ruinous to the paper. The editor may be the greatest journalist alive; his staff may be the flower of English journalism, and yet the inefficiency of a reader can ruin everything.

Continued

COAL-TAR PRODUCTS, WOOD DISTILLATION, CELLULOID, & MATCHES

Continued from page 5367

By CLAYTON BEADLE and HENRY P. STEVENS

COAL-TAR PRODUCTS

Coal-tar products are the result of subjecting coal to the process known as *destructive distillation.* By this we understand the decomposition of substances (in this case coal) by heat with the formation of products which are volatile. Destructive distillation differs from ordinary distillation in that the substances do not distil unchanged, and the products collected differ in chemical composition from the substances from which they were obtained. The plant required for carrying out processes of this kind does not differ essentially in principle from that employed for the purification and preparation of bodies by distillation. It consists, first, of a vessel or a retort in which the substance is heated and undergoes decomposition; secondly, a condenser, or apparatus for the condensation of the vapours given off; and thirdly, a receiver or receptacle for collecting and separating the products of distillation.

Constructive Distillation. Although the process may be regarded mainly as the breaking-up of more complicated products into simpler ones, nevertheless, alongside of this decomposition a certain amount of *synthesis*—that is, building-up of chemical compounds, or formation of substances —takes place from the first-formed products of decomposition. This is owing to the fact that such products of decomposition are not removed immediately they are formed, but remain for a certain time in the hot retort. Thus, if benzene be led through a red-hot tube, a certain proportion of acetylene is formed. On the other hand, acetylene led through a red-hot tube is partly converted into benzene. Now, as benzene and acetylene are both formed on the destructive distillation of coal, we see that the formation of either of these substances is not the simple process of decomposition which it might appear to be at first glance.

Coal-tar. An enormous amount of this substance is produced yearly, and most of it is derived from the destructive distillation of coal. The coal carbonised in London and surrounding districts in 1902, according to private sources of information, we find to be nearly 4,000,000 tons, yielding, say, 200,000 tons of tar. The yield of tar will depend upon the variety of coal and temperature of distillation, etc.

Tar is a liquid heavier than water, its specific gravity being 1·1 to 1·2. The composition of the tar will depend upon the quality of the coal. Thus, cannel coal yields a tar of specific gravity 1·1, poor in aromatic compounds. Newcastle coal gives tar rich in naphthalene and anthracene, and Wigan coal gives tar rich in benzene and phenol (carbolic acid). Boghead and bituminous shales, when mixed with coals, give inferior tar containing excess of paraffin hydrocarbons, which cannot be separated from the tar by the usual processes.

The composition of tar is also largely dependent on the temperature of the retorts. At low temperatures, chiefly paraffin, olefins, and higher phenols are formed, and the quantity of the permanent gas produced is small. At higher temperatures, although olefins and also acetylenes are still formed, the paraffins are mostly decomposed, with the separation of carbon in the retorts and the formation of lower paraffins. There are also formed aromatic hydrocarbons and "condensed ring" bodies, together with lower phenols. The proportion of permanent gas is much larger than at lower temperatures. As almost all coal is a residue from the gasworks, and as prices of tar have been much lower of recent years, the object of the gasworks is to produce as much gas as possible, so that distillation is carried on at high temperatures, which tends to reduce the yield of tar. The temperature of working in England is about 1,100° C., and the average yield of tar may be taken as 5 per cent. The table below gives some idea of the yields of tar and gas liquor which can be obtained from one ton of different kinds of coal (Stohmann-Kerl):

Coal	Tar	Gas Liquor
Boghead cannel	733 lb.	—
Newcastle	98 „	60
Wigan	218 „	162
Lochgelly	225 „	340
Pelton Main	112 „	112
Lismahago cannel (1)	594 „	4
„ „ (2)	603 „	4
Ramsay's Newcastle cannel	295 „	7
Derbyshire deep seam	219 „	179

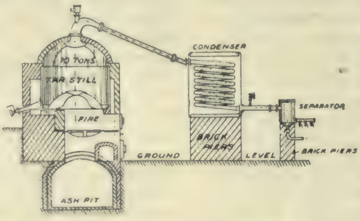
Coal-tar is also obtained in some cases by utilising the waste products from coke ovens. Small quantities are also obtained from blast furnaces, gas producers, and water-gas plants.

Crude Tar. Although a number of valuable products are got by distilling coal-tar, some outlet can be found for it in the crude state. In the first place, it can be burnt as fuel. This is usually done underneath the retorts themselves by running the tar on coke. In this way, one part of tar may be burnt for every four parts of coke. A number of appliances have been devised for burning tar in a furnace in a similar manner to petroleum. It may also be used for preserving timber and other building materials, and as tarred felt for roofing, or again as an antiseptic in virtue of the carbolic acid, etc., that it contains. It is, however, more usual to separate these substances than to make use of the tar itself.

Tar forms a suitable substitute for resin in the preparation of lampblack; but a partially purified or prepared tar is now used, as the crude tar contains some very volatile constituents, and these would find their way into the lampblack. It is usual to remove these by first distilling off the water and more volatile portions of the tar. The tar is burnt in brick ovens, and the soot is deposited in a number of chambers. Several contrivances have been devised for bringing about rapid deposition of the soot, such as systems of "baffle-plates"—that is to say, obstructions built into the flues, not unlike the arrangement of laths in a venetian blind, and devices for giving a whirling motion to the soot-charged vapours, so that the particles of soot strike the walls of the collecting chambers and are

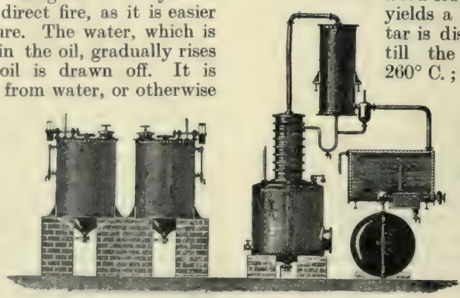
deposited. Lampblack contains a certain quantity of tarry matter, and for many purposes it requires to be refined. This is done by igniting in sheet-iron cases with lids luted on. After ignition, the cases are left some time to cool, as soot loses its heat slowly, and would catch fire if exposed to the air while still hot. The refined product has a better covering power [see Paints and Polishes, page 5141], and is used by printers' ink and colour makers [see Inks, page 5366]. Tar has also been used as a binder for briquettes, and for making the "basic" lining of Bessemer converters.

Distillation of Coal-tar. Coal-tar is a mixture of a great number of different substances. Lunge, in his treatise, gives a list of nearly 200, many of which are extremely valuable, and are the mother substances for the manufacture of aniline dyes, artificial perfumes and essences, pharmaceutical preparations and disinfectants. The problem we have to face is the separation and the purification of the individual substances. Although the actual proportion of some of these substances present in the tar is very small, the quantity of tar worked up is so large that considerable amounts of these substances can be obtained. Thus, the yield of anthracene, the mother substance of the alizarine dyes, is less than 1 per cent. of the tar distilled.



1. GENERAL ARRANGEMENT OF TAR DISTILLING PLANT
(Leeds and Bradford Boiler Co., Ltd.)

The tar is first freed as completely as possible from watery ammoniacal liquor, which distils over from the retorts with the tar [see Coal Gas, and also Sulphuric Acid, page 4625, and Alkalies, page 4770]. This is often effected by allowing the tar to stand in cisterns preferably fitted with steam coils. By a steam coil is meant a coil of steam pipe by which the liquid in the cistern can be heated. Such indirect methods of heating are in many cases preferable to heating by a direct fire, as it is easier to regulate the temperature. The water, which is merely held mechanically in the oil, gradually rises to the surface, and the oil is drawn off. It is important to free the tar from water, or otherwise it might "bump" or boil explosively when distilled. Distillation is the method used to separate the constituents of which coal-tar is composed, but the method allows of only a very rough separation in one operation. The different portions or "fractions" of the distillate collected are in themselves complex mixtures. This partial separation, however, is all that is necessary in some cases, while in others it does not pay to carry the separation further. Thus, creosote oil, one of the fractions, is far better suited for "creosoting" than the crude tar from which it was obtained.



2. PLANT FOR RECTIFYING BENZENE
(F. H. Meyer, Hannover)

Where it is necessary to carry separation or purification further, as in the coal-tar dye industry, the fractions are themselves redistilled, and various other chemical means are employed which we shall briefly touch on in what follows.

The Coal-tar Still. The coal-tar is treated in stills, mostly upright and cylindrical in form, the bottom being spherical and curved inwards, as in the illustration. Figure **1** shows the general arrangement of still, condenser, and separator; **3** is a photograph of the still lying on one side. The still is provided with a dome-shaped cover and still head, inlet and outlet cocks, and manhole. It should also be fitted with some form of safety-valve. Modern plants are often provided with a system of steam pipes, reaching to the bottom of the still, so that superheated steam can be used for finishing off the process. The condenser is simple in construction, put together from lengths of cast-iron pipes with elbow joints or from semicircular wrought-iron tubes. The condensing worm so formed lies in a cooling tank, as in an ordinary still. Noxious gases are given off during the distillation, and carry with them a small proportion of the more volatile constituents. They must be treated in a "scrubber," not so much to recover these constituents, but to absorb the noxious gases such as CS_2, H_2S and NH_3, before they escape into the air.

Gaster's Process. We must take especial care in working the stills that the contents do not boil over, especially when the distillation begins. According to Kohler, this is often caused by an excessive percentage of *free carbon.* This free carbon, which may be present in the tar to the extent of 20 per cent. to 25 per cent. by bulk, has a tendency to settle down to the bottom, and as it is a bad conductor of heat, there is considerable danger of overheating and burning out the bottom of the still, especially during the last stages of the operation.

Gaster has patented a method of separating the carbon, itself of considerable value, for making electrodes [see Electrochemistry]; further, the oil freed from carbon distils better and yields a better class of pitch. The tar is distilled in the ordinary way, till the temperature rises above 260° C.; the operation is then interrupted and a low boiling naphtha added to the partly cooled contents of the still. The whole is forced into a filter press, where the carbon is retained and washed by a further quantity of naphtha to remove the rest of the tarry matter. The carbon is left as fine powder, and the tar oil, after distilling off the naphtha, can be further treated as required.

Separating the Distillate into Fractions. The distillate is collected in a number of fractions (Lunge). The average yields given by Mills are as follows:

1. First runnings, up to 105° C. or 110° C.	2·5 per cent.
2. Light oil, up to 210°	5·0 "
3. Carbolic oil (for carbolic acid and naphthalene up to 240° ..	} 27·5 "
4. Creosote oil, up to 270° ..	
5. Anthracene oil, above 270° ..	10·0 "
6. Pitch (with this yield the pitch is hard)	55·0 "

The more important substances obtained from these several fractions are indicated by the titles. The "first runnings," consisting of naphtha, come over with some aqueous ammoniacal liquor and float upon it.

The "light oils," or "second runnings," are collected until they appear neither to sink or to float in water—that is to say, until they are as heavy as water. This fraction consists of benzene, toluene and "higher homologues" [for which see Organic Chemistry], and a certain amount of carbolic acid, naphthalene and other substances. The greater part of the carbolic acid and naphthalene are contained in the third fraction, the "carbolic oil," and as naphthalene is a solid substance at the ordinary temperature, the solidification of a few drops of the distillate on a piece of cold iron shows when it is time to change the receiver and to begin collecting the carbolic oil.

The Light Oils and their Treatment. To separate the substances contained in the light oils, they are fractionally distilled or rectified in a plant similar to a tar still.

Wurtz states that after two fractionations, the following results are obtained:

(*a*) Product up to 120° containing benzene and toluene.

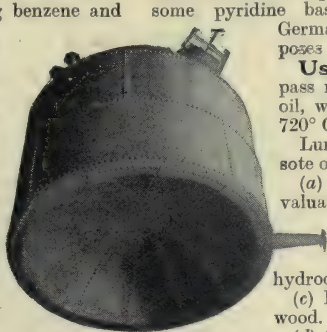
(*b*) Product from 120° to 127° containing solvent naphtha No. 1.

(*c*) Product from 127° to 140° containing solvent naphtha No. 2.

(*d*) Product from 140° to 150° containing solvent naphtha No. 3.

(*e*) Residue, which will contain the phenol and naphthalene.

Product (*a*) is further purified by washing with chemicals, usually strong sulphuric acid and alkali. Plant for doing this is described under Washing Turpentine [see Wood Distillation]. It then undergoes further rectification by steam. The plant is shown in 2; on the left are the two washers, and on the right the distilling plant.



3. TAR STILL, SHOWING CURVED BOTTOM
(Leeds and Bradford Boiler Co., Ltd.)

Benzene is a body of great importance, as it can be converted into nitrobenzene or oil of mirbane, a substitute for oil of bitter almonds, and thence into aniline, the mother substance of many of the aniline dyes. The United Kingdom produces several million gallons of benzene yearly. Benzene and naphthalene are also used for solvent purposes, and for carburetting coal gas.

Carbolic Oil and Carbolic Acid. We now pass to fraction 3, the carbolic oil, which forms 7 per cent. or 8 per cent. of the total distillates. On cooling down, 25 per cent. to 30 per cent. of the naphthalene crystallises out. This substance is one of the most abundant constituents of coal tar, of which it forms 5 per cent. to 10 per cent. In the crude state it is used for carburetting gas. It is purified by hot-pressing—that is to say, pressing out the mother liquor while the mass is hot. [For chemical and physical characteristics of naphthalene and other bodies derived from coal tar, see Organic Chemistry.]

Naphthalene is the mother substance for making phthalic acid, and thence the phthalein colours, as for instance, eosine and phloxine, also β-naphthol and azo-dye derivatives, and in the manufacture of artificial indigo. The oil, from which the greater part of the naphthalene has crystallised out, is separated by a very beautiful chemical process devised years ago by the French chemist Laurent. It is treated with alkaline liquor (carbonate of soda), which combines with the carbolic acid, phenols and higher monologues (cresols), in virtue of their acid natures. The mixture left to itself will separate into two layers, an oily and an "aqueous" or watery layer, so that the resulting salts, carbolates, being soluble in the aqueous layer, can be removed, and the remaining oil contains higher "homologues" [see Pure Chemistry] of benzene, naphthalene, and pyridene bases. The operation is carried out in mechanical mixers, heated and agitated by a current of air or other means. [Illustrations representing similar mixers to these may be seen in the article on Wood Distillation.] As phenol is a stronger acid than the cresols, most of it may be removed from the oil, leaving the cresols behind, by adding alkali in successive small quantities. The liquor containing the carbolates is decomposed with sulphuric acid in a lead-lined "agitator" or "mixer."

Pure carbolic acid is obtained by distilling; the distillate passing over between 180° and 205° C., is allowed to crystallise and the crystals are separated from the mother liquor. The carbolic oil contains some pyridine bases, which are used largely in Germany for "denaturing" purposes (rendering spirit undrinkable).

Uses of Creosote Oil. We pass now to fraction 4, the creosote oil, which distils between 240° and 720° C.

Lunge describes the uses of creosote oil as follows:

(*a*) Rectification, to obtain more valuable products.

(*b*) Passing through red-hot tubes, to obtain illuminating gas, and more readily saleable hydrocarbons.

(*c*) Pickling timber to preserve the wood.

(*d*) Softening hard pitch.

(*e*) Preparing varnishes.

(*f*) Lubricating oil, either in the crude state, or after undergoing special treatment.

(*g*) Burning for heating purposes.

(*h*) Burning for lampblack.

(*i*) Lighting.

(*j*) Carburetting gas.

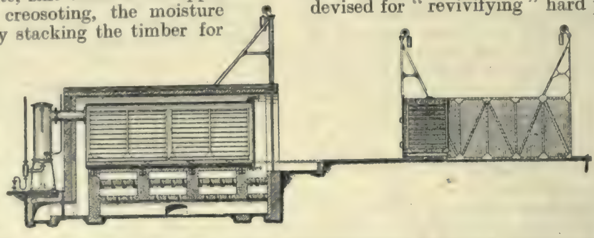
(*k*) As an antiseptic.

(*l*) Blue steaming of bricks.

For lubricating purposes the phenols ("acids") must first be removed. This is commonly effected by means of lime, which, being alkaline, combines with phenols, just as in Laurent's process. The resulting oil, when mixed with rosin oil and ozokerit (earth wax) yields a serviceable cart grease. For lighting purposes it is burned in special lamps, and produces a bright, roaring flame, such as may be seen in the streets at night where road repairs or building operations are carried on. As for antiseptic purposes, it would be better to separate those substances such as phenol, cresols, etc., to which the antiseptic properties of the oil are due. Owing to the expense of this treatment, the untreated oil is used in the form of an emulsion by mixing with a soap such as a soda rosin soap [see Soaps, page 4963]. It will owe its activity as a disinfectant to the finely-divided state of the phenols, when prepared in the form of emulsions. Such substances are sold as "creolin," "cresolin," "disinfectol," etc. Others, "sapocarbol," "lysol," are prepared

(German Patent 52,129) by mixing the oil with resin or linseed oil and saponifying with caustic potash and spirit of wine under a "reflux" condenser. Thick oils are thus obtained which have the advantage of dissolving easily in water.

Pickling Timber. For preserving wood, *creosoting* is more commonly adopted than any other method (others consist in heating wood with solutions of corrosive sublimate, zinc chloride or copper sulphate). Before creosoting, the moisture must be removed by stacking the timber for six months or so. The operation is carried out in special plant. The wood is put into a boiler capable of withstanding considerable pressure. The air is then exhausted and hot oil run in to fill the whole boiler with the exception of a dome situated on the top. The air exhaust is kept working, and, under the influence of the hot oil, all air and moisture is withdrawn from the pores of the wood. The contents of the boiler are then subjected to pressure, by which the oil is driven into the pores, from which the air has been sucked out. In this process (Boulton, British Patent 1854–1879) wet, unstacked wood can be used without previous treatment. The method of creosoting or pickling can also be applied to sails, ropes, fishing-nets, etc.



4. HORIZONTAL RETORT, WITH COOLING-BOX FOR THE CHARCOAL

According to Williams, pyridene and quinoline bases are the active constituents in preserving timber. The creosoting is, however, both a chemical and mechanical process, and the "indifferent oils" play an important part, leaving out of consideration the chemical effect of the phenols and the acids. The oil being forced into the wood seals the pores and prevents the entrance of water.

The Mother Substance of Many Dyes. We come now to fraction 5, the anthracene oil (green oil, green grease, red oil), which boils above 270° C. (thermometer in vapour). It consists largely of solids, which crystallise out on cooling, and of which the most important is anthracene. These solids are separated by pressing, the residual oil going back to the heavy oil. This separation may be effected by filtering through canvas bags by means of filter or hydraulic presses. The residual mass contains about one-third its weight of anthracene. It is then powdered and washed with naphtha in closed iron cylinders provided with mechanical agitators and heated by a steam coil. The naphtha is, of course, recovered by distillation. It leaves behind a number of hydrocarbons, especially phenanthrene [see Organic Chemistry], which are used for making lampblack.

Crude anthracene is a brownish-green mass. Final purification is effected by sublimation. In England a larger yield of anthracene (London tar 0·8 per cent. to 0·9 per cent.) is obtained than on the continent (German and Dutch works, 0·3 per cent. to 0·4 per cent.). The United Kingdom produces about 6,000 tons of a 30 per cent. product annually. Germany consumes 1,400 tons *pure* anthracene in the alizarine dye works.

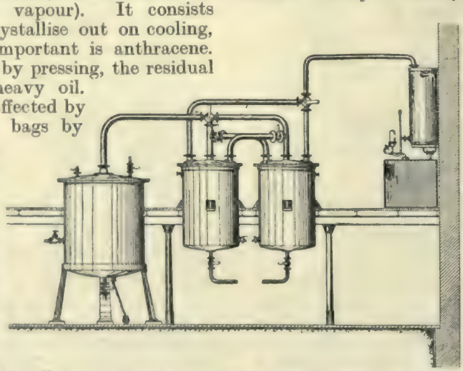
Coal-tar Pitch and its Uses. The residue left in the retort will vary in quality according to the amount of oil distilled off, yielding either a soft or hard pitch. For the manufacture of patent fuels soft pitch is preferred, and processes have been devised for "revivifying" hard pitch, by incorporating with it creosote oil or crude tar. Tar pitch is is largely used for making varnishes [see Paints and Polishes, page 5141], and also as asphalt for paving. In the latter case it is a substitute for natural asphalt, but only in combination with the latter [see page 2425]. Pitch may also be redistilled in special ovens in order to obtain a further yield of the valuable anthracene. Coke is left behind at the end of the operation.

WOOD DISTILLATION

In the various countries where there is a plentiful wood supply, particularly in Scandinavia, Germany, and North America, a portion of the output is utilised in the manufacture of chemical products by subjecting the wood to destructive distillation.

Wood consists essentially of 30 per cent. to 60 per cent. cellulose with about 12 per cent. of moisture and a small quantity of resin, mineral matter, etc. After deducting moisture, common woods contain about 50 per cent. of carbon and 6 per cent. of hydrogen.

The effect of heating is, in the first place, to drive off water, after which the wood begins to char and volatile decomposition products are given off, which are condensed by suitable means. They consist chiefly of methyl alcohol or wood spirit, tarry substances, and a weak solution of acetic acid, which collect in the receiver, while charcoal remains behind in the retort. Gases consisting mostly of carbon monoxide, carbon dioxide, and marsh gas, are also evolved. The charcoal is directly marketable. The gases are usually led back and burned under the retorts while the distillate is worked up on the following lines.



5. PLANT FOR TREATING CRUDE DISTILLATE. TRIPLE STILL SYSTEM

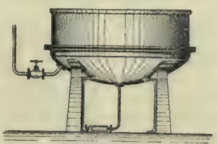
It is first roughly separated into aqueous liquor and tar. The aqueous liquor, which consists mainly of weak acetic acid, termed *pyroligneous* acid, can be employed directly for making iron mordant by dissolving scrap iron in it, the product consisting of a mixture of impure ferrous and ferric acetates, the so-called black liquor or iron liquor. Or litharge may be dissolved in it, and the resulting sugar of lead purified by crystallisation. It is, however, more usual now to subject the crude

pyroligneous acid to a careful separation. The liquid, which is dark brown in colour, and has a strong empyreumatic odour, consists in the main of:

5	to 10	per cent. of	acetic acid
0·1	„ 0·2	„ „	acetone
1·5	„ 3	„ „	wood spirit (methyl alcohol)
6	„ 10	„ „	tar
77	„ 87	„ „	water

and other products.

The acid is distilled, and the vapours led through milk of lime, which combines with the acetic acid and any other acid substances, while the greater part of the steam and wood spirit vapours pass on, and are collected in a suitable condenser.



6. PAN FOR CONCENTRATING CALCIUM ACETATE LIQUORS

Crude Products and Yields. We now have our crude products separated in three parts:

1. The tar which remains behind in the retort.
2. The solution of calcium acetate with a concentration of about 15 per cent.
3. The solution of wood spirit in water—of from 6 per cent. to 10 per cent. strength.

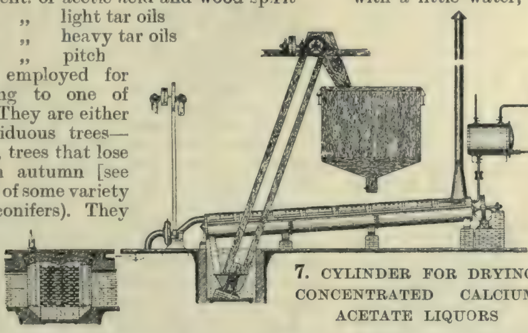
The crude calcium acetate liquors yield on concentration a *grey* calcium acetate containing 80 per cent. to 84 per cent. of the pure acetate which serves as raw material for the preparation of acetic acid and acetates. A brown acetate of lime is also manufactured containing 60 per cent. to 70 per cent. of the pure acetate. The crude wood spirit is rectified in special distilling plant (dephlegmators) fitted with condensers, and yields an 80 per cent. wood spirit, the raw spirit of commerce.

Returning now to the larger quantity of tar separated mechanically from the aqueous liquors, if this tar be distilled it can be separated into a liquor containing some acetic acid and wood spirit, a light and a heavier tar, and, finally, wood pitch (Stockholm tar), which remains behind in the stills.

The yields are approximately as follows:

20	per cent. of	acetic acid and wood spirit
5	„ „	light tar oils
10	„ „	heavy tar oils
60	„ „	pitch

The woods employed for distilling belong to one of two classes. They are either woods of deciduous trees—that is to say, trees that lose their leaves in autumn [see page 4676]—or of some variety of pine tree (conifers). They are treated on somewhat different lines. The wood of deciduous trees yields a maximum of wood spirit and acetic acid, while the tar is of little or no value. On the other hand, the wood of pine trees, of which usually the stumps and roots are employed, yields, in addition to a small quantity of wood spirit and acetic acid, a valuable pitch (Stockholm tar) and some turpentine.



7. CYLINDER FOR DRYING CONCENTRATED CALCIUM ACETATE LIQUORS

According to Rudnew the acetic acid obtained from 100 parts of different kinds of wood is as follows:

Linden ..	10·24 parts	Fir	5·2 parts
Birch ..	9·5 „	Cellulose from birch ..	6·2 „
Aspen ..	8·06 „	Cellulose from pine ..	5·0 „
Oak ..	7·9 „		
Pine ..	5·6 „		

The wood was "distilled" from glass vessels at 150° C. to 300° C.

The Still in Operation. We will now describe in more detail the process of distilling wood and the preparation of acetic acid, acetates, methyl alcohol and acetone.

Before the wood can be put into retorts for distillation it has to be stacked for one or two years in order to get it as dry as possible. It is taken from the drying sheds, put on to small trucks, and taken to the retorts. These consist of horizontal cylinders [**4**], which are heated so that the flames do not come into direct contact with the metal, but are arranged so that the hot flue gases surround them. This is necessary to prevent over-heating of the retorts and to subject the wood to as uniform a temperature as possible.

The water and other products formed are carried into tubes surrounded by a cold water-jacket, arranged so that they can be readily cleaned out should they get stopped up at any time. In these tubes the whole of the volatile matters are condensed with the exception of the gases. The former collect in a vessel or receiver. On their way they pass through a small separator, and a pipe from this leads the gases back to be burned under the retort. A number of these retorts are arranged alongside one another.

In the first stages the distillate is clear, and has little odour, being almost free from acetic acid and tar, but later on the distillate becomes darker in colour owing to the presence of a considerable proportion of tar, while gases are given off in larger quantities. In the final stages the gas evolution slackens, and the condensed liquids consist almost entirely of tar. When the distillation is complete, the front of the oven is opened, and workmen immediately seize hold of the basket in which the wood lay in the retort and draw it out. As soon as the hot charcoal comes into contact with the air it catches fire. This is put out by sprinkling it with a little water, and the charcoal is allowed to cool in an iron vessel with the lid well luted on, so as to prevent access of air. The cooling-box is seen on the right-hand side of **4**. The distillate from the different retorts collects in large wooden vats, where the tar separates out. and is run out from a tap at the bottom from time to time, while the aqueous liquors overflow from the vat into a series of vats—five in all—where the tar settles. In the last vat practically no tar at all is found.

Separation of the Products. The crude aqueous liquors are pumped up into a cistern, whence they are run into a large copper retort [**5**], which is in connection with two smaller copper vessels containing the milk of lime. The large retort is heated by a steam coil, and the products, consisting chiefly of methyl alcohol and acetic acid, are driven over and collect in the smaller vessels containing the milk of lime (triple still system). The plant is arranged so that the vapours pass through either or both of the milk of lime vessels. The greater part of the steam and methyl alcohol pass on, and are condensed in a suitable condenser, seen on the right hand of **5**.

The specific gravity of the distillate is taken continuously by running the liquor through a vessel

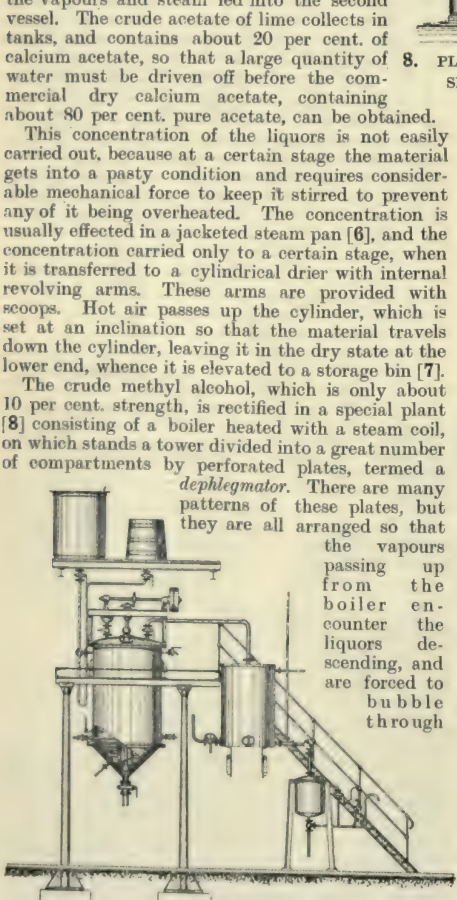
provided with an hydrometer. The first portions, being much richer in methyl alcohol, show a low specific gravity. When the instrument shows that the specific gravity of the condensed vapours is practically equal to that of water, it may be taken that the whole of the methyl alcohol has been driven off. There is, therefore, no need to condense the vapours, which come over in the latter part of the operation, as they consist wholly of steam.

Take the case of 1,000 gallons of crude liquor from beech wood, which will contain about 275 lb. of wood spirit; at least 270 gallons of weak aqueous wood spirit will distil over before the whole of the wood spirit is condensed. The first portion, containing 30 per cent. to 40 per cent. of methyl alcohol, is usually collected apart in a separate tank; the weaker liquors, containing up to 15 per cent. of wood spirit, are also separately collected.

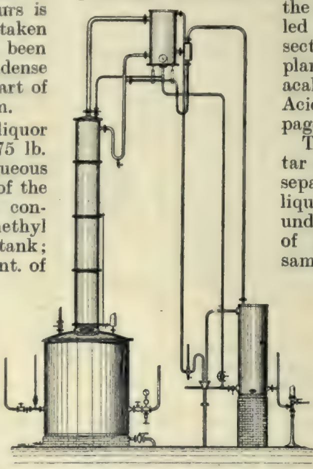
Before all the wood spirit is driven out of the big copper retort in which the liquor was originally placed the acetic acid will begin coming over, and as soon as the milk of lime in one of the smaller vessels shows an acid reaction to litmus it is run out, and the vapours and steam led into the second vessel. The crude acetate of lime collects in tanks, and contains about 20 per cent. of calcium acetate, so that a large quantity of water must be driven off before the commercial dry calcium acetate, containing about 80 per cent. pure acetate, can be obtained.

This concentration of the liquors is not easily carried out, because at a certain stage the material gets into a pasty condition and requires considerable mechanical force to keep it stirred to prevent any of it being overheated. The concentration is usually effected in a jacketed steam pan [**6**], and the concentration carried only to a certain stage, when it is transferred to a cylindrical drier with internal revolving arms. These arms are provided with scoops. Hot air passes up the cylinder, which is set at an inclination so that the material travels down the cylinder, leaving it in the dry state at the lower end, whence it is elevated to a storage bin [**7**].

The crude methyl alcohol, which is only about 10 per cent. strength, is rectified in a special plant [**8**] consisting of a boiler heated with a steam coil, on which stands a tower divided into a great number of compartments by perforated plates, termed a *dephlegmator*. There are many patterns of these plates, but they are all arranged so that the vapours passing up from the boiler encounter the liquors descending, and are forced to bubble through them. In this way the portions containing water are returned to the boiler, while the more volatile portions, consisting of methyl alcohol, escape from the top of the tower and are led into a condenser. A sectional drawing of similar plant for treating ammoniacal liquors is shown in the Acid and Alkali section [**20**, page 4776].



9. PLANT FOR AGITATING TAR OILS OR TURPENTINE WITH CHEMICALS, AND DISTILLING THE PRODUCT



8. PLANT FOR RECTIFYING WOOD SPIRIT (METHYL ALCOHOL)

There remains only the tar to be dealt with. That separated from the aqueous liquors is usually burned under retorts by means of sprays, in exactly the same manner as coal-tar is burnt.

The larger quantity of crude tar is subjected to a distillation to recover the acetic acid and methyl alcohol contained in it.

Coniferous Woods. The foregoing description applies chiefly to beech wood and the wood of other deciduous trees, and requires some modification if applied to pine woods, as the latter contain resin, which yields turpentine when the wood is distilled.

As turpentine is a valuable product, the distillation of pine woods is a profitable operation, in spite of the much smaller yield of acetic acid and methyl alcohol. The turpentine collects in the same receiver with methyl alcohol, after the vapours driven off from the large retort have passed through the milk of lime, and separates out as a distinct layer, which may be drawn off.

Owing to the presence of small quantities of allyl compounds, it has a penetrating smell, and the vapours irritate the eyes. No amount of further distillation will rid the crude turpentine of this impurity, and recourse is had to chemical treatment. The crude turpentine is run into an iron vessel provided with mechanical agitators [**9**], and a quantity of caustic soda liquor added. This extracts some of the impurities, such as aldehydes, phenols, etc., the liquor changing to a brown colour. It is run off, and the oil washed with water in a similar manner—that is, water is run in, the agitators set going, and after sufficient treatment the water run off again. Following this washing with soda, the crude turpentine is treated in a similar manner with sulphuric acid, and finally rectified.

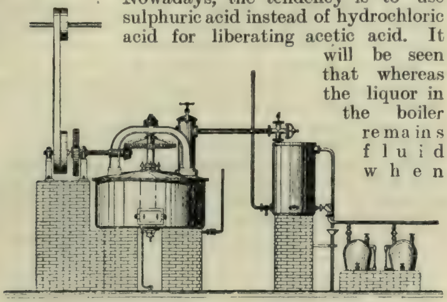
Acetic Acid. As already mentioned, the crude sodium acetate is the material from which the pure acetic acid is prepared. For this purpose the sodium acetate is acted on with either hydrochloric or sulphuric acids. For 100 lb. of calcium acetate 115 lb. of hydrochloric acid of 20° to 21° B. is required. The two are thoroughly stirred up and allowed to stand, when the small quantity of tar contained in the acetate of lime rises to the surface and is skimmed off. The liquor is then heated in copper boilers by means of steam coils, and the acetic acid vapours are driven off and condensed.

Theoretically, 100 parts of the crude grey acetate of lime, containing 82 per cent. of the pure substance, should yield 60 parts of glacial acetic acid; but this yield is never obtained in practice, as a

certain amount of acetic acid is held back by the chloride of calcium liquor remaining in the boiler.

Acetic acid prepared by this method is usually of about 45 per cent. strength, and as such is brought into the market. It could be concentrated by rectification, in plant built on similar lines to that used for rectifying methyl alcohol [8].

Nowadays, the tendency is to use sulphuric acid instead of hydrochloric acid for liberating acetic acid. It will be seen that whereas the liquor in the boiler remains fluid when using the latter acid, this is not the case when working with sulphuric acid, as insoluble calcium sulphate is formed in the reaction. This necessitates fitting the boiler with mechanical stirrers [10].



10. PLANT FOR MAKING CRUDE ACETIC ACID BY SULPHURIC ACID PROCESS

Further, when using sulphuric acid certain other decompositions take place simultaneously, with the result that some sulphur dioxide is formed, and the acid is not so pure as that obtained by the hydrochloric acid process. The difficulty may be got over by adding an oxidising agent, such as pyrolusite, to the contents of the still. The sulphuric acid process has, however, this great advantage, that as the liquor is not diluted, the acetic acid is obtained in a more highly concentrated state—that is, as high as 75 per cent.

The more concentrated the acid the higher the temperature at which it boils. By distilling in a suitable retort, fitted with a dephlegmator, the most concentrated acid —the so-called *glacial* acetic acid—is obtained. The term "glacial" is given to it on account of its property of solidifying to a hard, ice-like mass in moderately cold weather.

In many cases it still contains a little sulphurous acid and other organic impurities. To obtain the absolutely pure acid for pharmaceutical or similar purposes, it is distilled over permanganate or bichromate of potassium in a copper retort provided with a silver condenser. It should be colourless and water clear, and should not decolorise a solution of potassium permanganate.

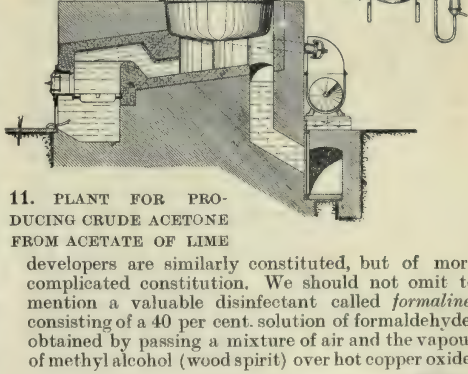
Acetone. Acetone is prepared in large quantities for use in the celluloid industry, and for gelatinising nitro-cellulose in the manufacture of smokeless powders. Very large quantities are imported into this country by our Government for this purpose. Acetone is obtained on a large scale by distilling calcium acetate. Special forms of retorts are employed, sometimes provided with stirrers similar to those used for making acetic acid by the sulphuric acid process [11].

The yield obtained depends very much upon the manner in which the crude material is heated, and the retorts are arranged so as to be surrounded by the hot flue gases. At first, water distils over, as even "dry" acetate of lime contains some moisture in combination, after which nothing comes over for a little while, until the acetone itself makes its appearance as a dark brown distillate with a characteristic odour.

During the process, inflammable gases are given off, owing to secondary decompositions, and these gases must be removed from the retort by a steam jet before the latter can be opened. 240 lb. of crude acetate of lime yield about 22 lb. of crude acetone, and the jet of steam led into the retort at the end of the operation carries over about another 4 lb. The illustrations in the wood distillation section are from machines constructed by F. A. Meyer, Hannover-Hainholz.

Coal-tar and Wood Products. The different products obtained in the distillation of coal and wood form the raw materials for the manufacture of a host of valuable substances which include most of the disinfectants and dyes, as well as synthetic remedies, artificial perfumes, and saccharin. From the chemical point of view, the composition of these substances is extremely complicated, and their manufacture not less so. A thorough knowledge of organic chemistry is necessary for anyone who desires to follow, step by step, the stages by which these substances are built up from such mother substances as benzene, toluene, phenol, cresol, naphthalene, and anthracene. Besides these coal-tar products, we have the acetic acid, acetone, and methyl alcohol as raw materials obtained from wood. We must, therefore, content ourselves in the majority of cases with a bare enumeration of some of these products. It will be realised that even this must be done inadequately, when we consider that there are, for instance, several hundred coal-tar colours known.

Disinfectants. For use as a disinfectant, a chemical substance is not required in a high state of purity, and consequently we have already had occasion to mention phenol and cresol, and other products of the distillation of coal, which may be applied in the crude state. A number of other disinfectants which have been prepared possess a similar chemical constitution, and are known as hydroxy derivatives of benzene and its homologues. One of these, pyrogallic acid, finds extensive use as a developer in photography. Most of the other photographic developers are similarly constituted, but of more complicated constitution. We should not omit to mention a valuable disinfectant called *formaline*, consisting of a 40 per cent. solution of formaldehyde, obtained by passing a mixture of air and the vapour of methyl alcohol (wood spirit) over hot copper oxide.



11. PLANT FOR PRODUCING CRUDE ACETONE FROM ACETATE OF LIME

Excess of methyl alcohol is always used in practice, and some 30 or 40 per cent. unacted upon is recovered in a subsequent operation. The greatest care is necessary in maintaining the right proportions of methyl alcohol vapour and air, otherwise disastrous explosions may take place, or else the oxidation may go too far, so that the whole of the formaldehyde is oxidised to formic acid, with rise of temperature.

Coal-tar Colours. These are sometimes incorrectly termed *aniline dyes*, for although some of the more important are derivable from aniline and its congeners, this is by no means always the case. The aniline dyes are, in the first instance, derived from benzene, toluene, naphthalene, and other hydrocarbons, by acting on them first with nitric acid, to give the corresponding nitro-compounds, of which nitro-benzene is the simplest representative.

It is a yellow oil, smelling of almonds (essence of mirbane). These nitro-compounds are reduced with iron or zinc in hydrochloric acid solution, yielding aniline, toluidene, naphthylmine, etc.

$$\underset{\text{Benzene}}{C_6H_6} \rightarrow \underset{\text{Nitro-benzene}}{C_6H_5 . NO_2} \rightarrow \underset{\text{Aniline}}{C_6H_5 . NH_2}$$

Aniline is a colourless oil of peculiar odour, which, together with analogous substances, yields the dyes of the rosaniline group, including magenta and fuchsine, and a great number of others. There are also the indulines and safranines, "basic" dyes of a blue or darker shade. [For an explanation of the terms "basic," "acid," "adjective," and "substantive" dyes, see Paints, page 5141]. Aniline black, made by carefully oxidising aniline, is of importance in cotton printing. Methylene blue is an important sulphur containing dye. Passing from the aniline dyes we come to the phenol dye-stuffs—mostly acid dyes—nitro-derivatives of the phenols. Picric acid (trinitro-phenol), a strong, yellow dye, may be taken as an example. One part in 1,000 will dye silk a distinct yellow. Victoria yellow and Martius' yellow are other dyes of this class. Naphthalene oxidised to phthalic acid combines with the phenols to yield the phthaleïn colours; some of the best known are erythrosine, eosine, and phloxine. In addition, there are the rosolic acid and indo-phenol dyes.

Artificial Madder and Indigo. The third important group comprises the azo dyes. They are characterised by the azo grouping, composed of two nitrogen atoms ($-N = N-$), in combination with an amido (NH_2) group (amido-azo compounds) or a phenolic (OH) group (oxy-azo compounds). The simplest representatives will be:

Amido-azo benzene $C_6H_5 - N = N - C_6H_4\ (NH_2)$

Oxy-azo benzene $C_6H_5 - N = N - C_6H_4\ (OH)$.

Colouring matters of this type, but usually of more complicated constitution, are known respectively as *chrysoidines* and *tropæolines*. They are mostly yellow, brown, or scarlet dyes. As examples, we may cite Bismarck brown, crocein scarlet, and phenylene brown. Methyl orange, used as an indicator [see Acids and Alkalies] is also an amido-azo compound.

Anthracene is the basis of another important group, which includes alizarine (the artificial madder) and numerous other dyes, alizarine orange, alizarine blue, purpurine, and many similar substances.

Quinoline and acridine, two other coal-tar products, yield valuable dyes. Finally, we have artificial indigo, now manufactured on a commercial scale, and which is replacing the natural product. The chemical reactions involved in its manufacture are exceedingly complicated.

Artifical Perfumes and Flavouring Matter. Like the coal-tar colours we have just discussed, the nature of these substances is generally very complex, and they may conveniently be divided into two classes. There are, firstly, the synthetic products, which are, as far as we can judge, identical with the naturally occurring substances. Secondly, there are artificial products, usually mixtures, of different chemical substances, not identical with the natural product, but closely resembling it in odour or flavour.

Oil of Bitter Almonds and its Substitutes. To take the simplest instance we can think of, natural oil of bitter almonds is formed by the hydrolysis of a substance called *amygdalin*, which, owing to the presence of a natural ferment or enzyme (emulsin) occurring with it in the bitter almond, is decomposed (hydrolysed) with the formation of benzaldehyde, to which the odour and flavour of bitter almond is due.

Now, benzaldehyde, C_6H_5CHO, can be synthesised (built up) artificially from toluene, a hydrocarbon allied to benzene, occurring in the distillate of coal-tar. Hence benzaldehyde is to be regarded as a true synthetic product. Its manufacture on a commercial scale has been brought about through the following stages: (1) isolation and examination of the natural oil resulting in the elucidation of its chemical constitution; (2) the synthesis of this substance from simple commercial products, in this case toluene, as a result of laboratory work, based on purely theoretical considerations; (3) the adaptation and, if necessary, modification of laboratory work, to the conditions of commercial manufacture.

Leaving now the true synthetical products, we come to the second class of artificial substances. As a result of research in the laboratory, a substance, nitro-benzene, $C_6H_5NO_2$, was obtained by nitrating benzene. It is a yellow oil (benzaldehyde is colourless), having an odour strongly resembling oil of bitter almonds, and is largely used for flavouring, under the name of "essence of mirbane," to replace the more expensive benzaldehyde.

Essence of Violets. Whether for flavouring or for perfumes, it is necessary to use only very small quantities of the artificial products. In a concentrated condition, their taste and smell are usually quite different, and even unpleasant. It must be remembered that the natural substances which give the characteristic flavour and perfume to fruit and flowers are present only in minute quantity. This has added considerably to the difficulties of chemists in attempting their synthesis and manufacture on a commercial scale. It has been extremely difficult to procure sufficient for analysis except at impossible prices. Tiemann and Kruger's synthesis of ionone, the perfume of violets, may be cited as an instance. The odour of dried orris or iris root is very similar to that of violets, and as these chemists were unable to procure sufficient violet essence for their experiments, they were forced to work with extract of orris root, assuming the odoriferous principle to be the same in both cases. In the course of their work they isolated a substance, *irone*, from oil of orris, and in attempting to synthesise this body they eventually obtained a substance (*ionone*) very similar to, if not idenical with, the body they were in search of.

Ionone is sold as a 10 per cent. solution in alcohol, but its odour in concentrated condition is quite unlike the odour of violets it possesses when diluted. One part of this solution will produce 100 times its weight of triple extract when diluted with spirit,

Natural and Artifical Products Contrasted. It is not, however, advisable to employ ionone merely diluted down with spirit in this manner. Somehow or other, the odours of these chemical products, even when they are identical with the natural substances, are harsher and less refined. This is probably due to the presence of traces of other substances, and much may be done to improve the artificial products by suitable blending. For this purpose we may use mixtures of artificial substances, or mix them with the natural products; thus, in preparing extracts or scented soaps, the odour of ionone is much improved by the addition of a small quantity of oil of orris.

Many flavouring matters are poisonous in large quantities. A case recently occurred (March, 1906) in a biscuit factory, where one of the operatives drank a quantity of "essence of mirbane," intended for flavouring dough, with fatal results.

Other Synthetic Products. Some of the more important synthetic products are:

Oil of cassia or cinnamon. Cinnamic aldehyde, $C_6H_5 . CH : CH . CHO$, closely related to benzaldehyde or oil of almonds.

Oil of cloves. Engenol, a derivative of phenol.

Oil of wintergreen. Methyl salicylate, $C_6H_4(OH)COOCH_3$, obtained from salicylic acid, and indirectly from phenol.

Oil of garlic. Allyl sulphide $(C_3H_5)_2 . S$.

Oil of mustard. Allyl isothiocyanate $CS : N . C_3H_5$.

Niobe oil. Methyl benzoate, $C_6H_5 . COOCH_3$.

Bergamiol or artificial oil of bergamot. Linalyl acetate.

Vanillin is the active flavouring constituent of vanilla and is prepared synthetically from metamidobenzaldehyde.

The artificial product is often adulterated with acetanilide.

Coumarin is the odoriferous principle of the tonka bean, woodruff and other plants, and is contained in the perfume known as "foin coupé," or New Mown Hay. It was synthesised by Perkin from salicyl aldehyde.

A Perfume from Pepper. Heliotropin or piperonal, a substance having the odour of heliotrope, was originally prepared from piperine, the alkaloid extracted from pepper. It is now made commercially from safrol and is obtained in the form of white crystals. The perfume deteriorates unless the substance is stored in a cool, dark place. The heliotrope perfumes of commerce are made by blending heliotrope with vanillin or coumarin, the cheaper ones with acetanilide. While, in 1880, the price of heliotrope was £70 per lb. it is now 14s., so that the price has been enormously reduced. The same may be said of most other synthetic products; thus, vanillin cost £36 per lb. in 1880, while the present price is £1 12s. But in many cases, as with the essence of violets, the price is not likely to suffer much reduction until the patent expires. Hawthorn (aubépine), or odour of may blossom, is the substance known to chemists as anisic aldehyde and is obtained from phenol. It oxidises in air, so that it should be stored in well-filled bottles.

Artificial Musks. These are substances resembling but probably not identical with the natural product. They are usually prepared according to Baur's patents from toluene. This substance is made to react with butane by means of aluminium chloride and a portion of the distillate nitrated. It forms yellowish-white needles.

Artificial Neroli. Artificial neroli, or nerolin, is the methyl ether of β-naphthol. Bromelia, the odour of which is said to resemble pineapples, is the corresponding ethyl ether. By suitable blending, perfumes resembling lilac, hyacinth, lemon, roses, etc., may be obtained. We should also notice the series of esters of fatty acids having the taste and odour of fruit—for instance, ethyl butyrate, or essence of pineapple, ethyl pelargonate, or quince oil, amyl acetate, or pear essence, amyl valerate, or apple oil, etc.

Synthetic Remedies. These are chemical substances used in medicine, the majority of which are not met with in nature.

Fever and Headache Remedies

Antipyrine (analgesine), or phenazone. This substance was originally introduced as a febrifuge (used medicinally in cases of fever), but is also employed as an anodyne (to relieve pain). It is known chemically as *phenyl-dimethyl-isopyrazolone* and is obtained by the action of aceto-acetic ether on methyl-phenyl-hydrazine and crystallises in white tables or plates. The salicylate of antipyrine, or "salipyrine," is used for similar purposes. "Hypnal" is a compound of chloral and antipyrine.

Acetanilide, or antifebrin, already referred to under Perfumes, is obtained by boiling aniline [see Coal-tar Colours] and glacial acetic acid. It is represented by the formula $C_6H_5 . NH(C_2H_3O)$, and forms white prism-like crystals. Like antipyrine it is used as a febrifuge. "Antisepsin" is para-brom-acetanilide. Methyl-acetanilide is a specific against headache and known as "exalgin." It is also employed as an anti-rheumatic. Benzanilide, $C_6H_5 . CO . NH . C_6H_5$, is used as an antipyretic for children.

Phenacetin, or para-acet-phenethidine, is another antipyretic and anti-neuralgic, said to be free from objectionable after effects when administered medicinally. In a chemical sense it is related to aniline and may be regarded as a derivative of acetanilide. Its formula is represented constitutionally as follows: $C_6H_4(O . C_2H_5) . NH(C_2H_3O)$. It will be seen that it differs from acetanilide by the introduction of the ethoxy group, $O . C_2H_5$.

Metacetin, a substance having a similar therapeutic action to phenacetin is also chemically related to the latter. It is para-acet-anisidine.

Drugs to Induce Sleep

Hypnone, is acetophenone, $C_6H_5 . CO . CH_3$, and is prepared from benzene and acetyl chloride. It is used medicinally as a soporific (sleep producing).

Sulphonal, another soporific, as its name implies, contains sulphur. It is obtained by heating a mixture of acetone and mercaptan with hydrochloric acid. The allied substances trional and tetronal are also used as soporifics.

Numerous other synthetic remedies, mostly the products of German laboratories, have been put upon the market, but few ever find general application. Undoubtedly some of those we have cited are of the utmost importance, and no doubt the really valuable ones will come into general use. There are numerous products containing iron, sometimes in combination with albumen, for the purpose of rendering the former easier of assimilation by the human system. These and similar products are not of sufficient importance to detain us. It may be as well to remind the reader that of the

anæsthetics alcohol, ether and chloroform, the last two are obtained synthetically from the first.

Saccharin. This is a white crystalline solid substance with an intensely sweet taste which, according to the most recent information, is said to be five hundred and fifty times as sweet as ordinary cane sugar. That first produced was impure and not more than half as sweet. So accustomed are people to associating sugar with a sweet taste that saccharin is often regarded as a sort of concentrated sugar. This, however, is not the case, as there is no sort of chemical relationship between them. Whereas cane sugar is built up of carbon hydrogen and oxygen only, saccharin contains, in addition, nitrogen and sulphur. The raw material used in its manufacture is toluene, a hydrocarbon related to benzene, and one of the constituents of coal tar. The steps by which it is built up may be followed by placing the raw material, intermediate substances, and final product in order, as follows:

(1)	$C_6H_5 \cdot CH_3$	Toluene
(2)	$C_6H_4 \begin{cases} CH_3 \\ SO_3H \end{cases}$	o—Toluene sulphonic acid
(3)	$C_6H_4 \begin{cases} CO_2H \\ SO_3H \end{cases}$	o—Sulpho-benzoic acid
(4)	$C_6H_4 \begin{cases} COCl \\ SO_2Cl \end{cases}$	Dichloride of o-sulpho-benzoic acid
(5)	$C_6H_4 \begin{cases} CO_2H \\ SO_2NH_2 \end{cases}$	o—Sulphamido - benzoic acid
(6)	$C_6H_4 \left\{ \begin{matrix} CO \\ SO_2 \end{matrix} \right\} NH$	Saccharin.

Saccharin is of an acid nature and can be neutralised with soda. The sodium salt crystallises with two molecules of water, and has the advantage that it is much more readily soluble in water than saccharin itself. It is the chief constituent of the easily-soluble saccharins on the market.

CELLULOID

This product is made from paper or other forms of pure cellulose, by converting them into pyroxylin (guncotton or collodion-cotton), by treating with a mixture of sulphuric and nitric acids. The product, when washed and dried, may be added to melted camphor, and the two moulded together by strong pressure in a hot press, or otherwise closely incorporated, and finally dried and moulded; or the pyroxylin may be dissolved in a mixture of ether and alcohol, in which form it is known as *collodion solution*. If spread out as a varnish and the solvent evaporated, the residual transparent film is known as collodion or celluloid film, and, as we all know, is largely used in photography, for the cinematograph, and for many other purposes where a transparent film is required. There are many modifications and changes in methods of treatment, which space will not permit us to deal with in detail. [For collodion silk see Artificial Silks.]

Celluloid was first made by Hyatt, of Newark, United States of America, who used both the above-mentioned processes. Now a combination of the two processes is more often employed.

"Celluloid may be readily coloured by means of various pigments used either in solution or in suspension and added to the mixture of pyroxylin and camphor before it is subjected to pressure. 'Marbled' celluloid is made by pressing plates of the differently coloured material together. Imitation tortoiseshell, used largely for the manufacture of combs, etc., is made by squeezing together plates of transparent yellow celluloid with similar plates coloured with various shades of brown, etc.

"Celluloid is highly inflammable, but non-explosive even under pressure; hence, it may be worked under the hammer or between rollers without risk. It softens in boiling water, and may then be readily moulded or pressed into various forms. Its specific gravity varies slightly with its composition and the degree of pressure to which it has been subjected; it is usually about 1·35." For further details of the chemical details of manipulation, see Thorpe's "Dictionary of Applied Chemistry," from which the above quotation has been taken.

Great art is now displayed in the manufacture of innumerable articles familiar to us all through their world - wide application. It successfully imitates ivory, horn, bone, tortoiseshell, mother-of-pearl, and many other natural products, besides replacing ebonite, vulcanite, china, glass, etc. Celluloid can generally be recognised by the smell of camphor which it emits when briskly rubbed. But even this is reduced to a minimum, if not entirely eradicated, by skilful manipulation. Its chief drawback is its inflammability, which is now, however, largely reduced. Hundreds of different articles are made from celluloid or "Xylonite," the name given to it by the British Xylonite Company, Ltd.

MATCHES

A match is defined in Thorpe's "Dictionary of Applied Chemistry" as "an instantaneous fire producer, consisting of a short stem, rod, or tube, tipped at one or both ends with a composition or paste, inflammable by friction."

The lucifer match has come into existence within the last 70 or 80 years. Prior to this the production of fire by the kindling of suitable combustible materials was promoted by friction, at one time by the rubbing together of two stones, or later by flint and steel. The latter is familiar to many of us in the old flint-lock guns of our forefathers to be seen in the old armouries. The rubbing of two pieces of wood together is the method still employed by the North American Indian and the Polynesians, who obtain fire by rapidly rotating a pointed rod of dry, soft wood, called a fire-drill, against a block of harder wood.

It is impossible to deal with the history of the different substances employed and the different methods in vogue from the time of the "phosphoric taper" up to the present, or to refer to the various forms of vestas and cigar lighters. A mass of patents have been taken out by those connected with the industry, an account of which will be found in Thorpe's "Dictionary of Applied Chemistry."

The operations performed in the manufacture of wooden matches consist as follows:

1, Barking; 2, cross-cutting; 3, steaming; 4, splint-cutting; 5, drying the splints; 6, filling the dipping frames; 7, paraffining; 8, dipping; 9, drying the dipped splints; 10, racking out; 11, halving, or cross-cutting; 12, boxing.

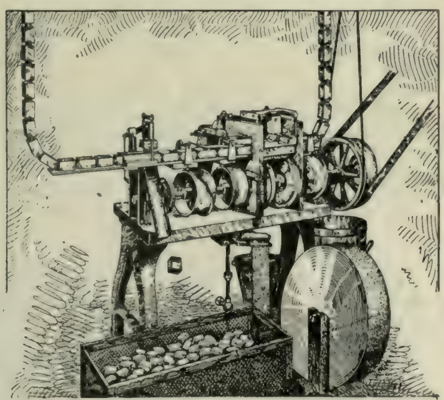
All of these processes were, and still are, involved in hand-made matches. Machines, however, are now almost universally employed.

Match-making Machinery. The blocks of wood, which come from Canada, are all cut to a uniform thickness equal to the length of the match and placed in position by hand, with the grain in the proper direction, on two endless leather travelling bands, between friction rollers to ensure their being fed towards the cutters at an even pressure. The dies or cutters are small steel bars of rectangular cross-section, having a hole the size of the match to be

cut drilled in them at one end. The dies are placed together side by side in rows of 48 or more, the whole being moved up and down by the action of a cam. A whole row of match splints or sticks are cut on the downward stroke. A plate carrying a row of pins then ascends under the bottoms of the match-sticks just cut, and drives them into counter-sunk holes in an endless chain of metal plates and without breaking them. This chain carries them forward with their points downward, where they are first of all dipped to the depth of an eighth of an inch into a bath of paraffin wax, the surface of which is kept at a definite level by an ingenious contrivance. The dipped matches, after travelling forward until the paraffin has had time to set, come in contact with a roller covered with the igniting composition, revolving at the same pace at which the matches are travelling, to ensure that the heads are not one-sided. The matches, after travelling round the machine in the endless chain, which runs over a number of drums, are punched out from this by a row of pins, corresponding in number and position to the holes in the chain, into empty boxes passing along an endless chain band ready to receive them, which, when full, passes on to a revolving table, where the covers are put on by hand, after which they are made up into packets of one dozen and parcels of six or twelve dozen. Very few girls are required for the handwork necessary on the output of a machine which in one day often equals 144,000 boxes, each box containing about 60 matches.

Machines are now constructed to do away with hand packing, the whole of the handling from start to finish being done by machinery.

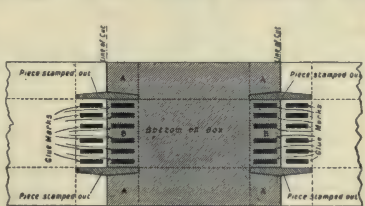
Box Making. "Chip" boxes, in which the chips are fastened together by pasted paper, are sometimes made by hand, but generally by machine. The strawboard boxes are made automatically from strips or reels of strawboard. The shape into which the material is cut and the places in which it is scored are shown in **12**. The strip is first scored by sharp wheels, so that it bends easily, and is then glued at regular intervals by means of an arm worked by a cam. The arm has twelve projections upon it, and it works up and down, in and out of a vessel containing melted glue, touching the cardboard at the top of its upward stroke, thus making a series of glue patches



12. MATCHBOX MAKING MACHINE

as shown in **12**, which will make the description clear. The strip is then fed forward, and holes are punched in it at regular intervals beside the glue-marks, as shown. These pieces are the only waste there is. After being glued and punched, the strip is automatically cut into suitable lengths, the line of cut running between two sets of glue-marks, as shown, and the piece cut off is then caught by a descending die, the edges A being turned upwards and inwards, and the edges B being pressed upwards and against them, and the box thus formed is forced into a metal former, a number of which are joined together in a continually revolving chain or band in the machine [**13**], in which it travels for one revolution of the band. By the time the revolution is complete the box is dry, and it is then automatically released from the "former," to fall into baskets or crates. Each of these machines will turn out about 80 boxes per minute.

The machine for making the strawboard covers is fed from a reel of cardboard, which on its passage is glued, folded over, and so converted into a tube. The tube then traverses the length of the machine twice, and during its passage it dries, and is turned over so as to get the join in a suitable place for future operations. The tube then passes between two printing rolls, which print the requisite design on each face. It is then cut off to proper lengths, and the last process is to bring the edge of each box-cover against a wheel dipping in melted glue, and then to throw white sand against the glue when it is still wet to form the friction surface. Such machines turn out from 800 covers per minute.



13. MATCHBOX BEFORE FOLDING UP

Wax Vestas. In making wax vestas, the cotton twist which forms the wicks is drawn from a large slowly revolving cylinder, through a bath containing a mixture of stearin and gum, through dies, and then on to another drum. They are passed slowly backwards and forwards from drum to drum until the taper is of the requisite thickness. The taper is then fed from the drums into a machine similar to that described for wooden matches, which cuts it into the length required, the chief difference being the manner in which the wax tapers or vestas are held, they being gripped by springs which hold them firmly for the operation of dipping in the igniting composition without pinching or marking them. The operation of dipping in paraffin wax is, of course, not necessary in the case of wax vestas.

Composition Room. In this room the igniting composition is made, in which the match is dipped in the manner already described. These compositions are made to formulæ known only to the makers. Messrs. Bryant & May do not use white or yellow phosphorus in the manufacture of their strike-anywhere matches, but a substance without smell and harmless to the operators. This is mixed with glue, chlorate of potash, certain other materials and colouring matter, the ingredients being weighed and carefully milled to ensure a thorough amalgamation.

Continued

Group 21
MATHEMATICS
38
GEOMETRY
continued from page 5338

SIMILAR FIGURES

Equiangular Triangles. Theorems Connected with Right-angled Triangles. Definition of Projection. Problems in Proportion

By HERBERT J. ALLPORT, M.A.

Proposition 55. Theorem

If one side of a triangle is divided, internally or externally, into segments proportional to the other sides of the triangle, the line joining the point of section to the opposite angle bisects that angle internally or externally.

With the figures of Proposition 54, let BC be divided at D, so that

$$BD : DC :: BA : AC.$$

It is required to prove that AD bisects the $\angle A$, internally or externally.

Proof. With the same construction as before, since AD is $\parallel$ to one side of the $\triangle BCE$,

$\therefore BD : DC :: BA : AE$ (*Prop.* 52).

But $BD : DC :: BA : AC$ (*Hyp.*).

$\therefore BA : AE :: BA : AC.$

$\therefore AE = AC.$

$\therefore \angle AEC = \angle ACE$

$= \text{alternate } \angle DAC.$

And $\angle FAD = \angle AEC.$

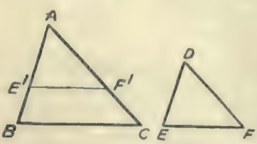
$\therefore \angle FAD = \angle DAC,$

i.e., $\angle A$ is bisected.

Proposition 56. Theorem

If two triangles are equiangular to one another, their corresponding sides are proportional.

Let ABC, DEF be two $\triangle$s in which $\angle A = \angle D$, $\angle B = \angle E$, and $\angle C = \angle F$.



It is required to prove that the three ratios $BC : EF$, $CA : FD$, and $AB : DE$ are equal.

Proof. Place the $\triangle DEF$ on the $\triangle ABC$ so that D falls on A and DE falls along AB. Then, since $\angle D = \angle A$, DF will fall along AC. Let E′, F′ be the new positions of E, F. Then,

$\angle E' = \angle B.$

$\therefore E'F'$ is $\parallel$ to BC.

$\therefore AB : AE' :: AC : AF',$

i.e., $AB : DE :: AC : DF.$

Similarly, by placing $\triangle DEF$ on $\triangle ABC$ so that E falls on B, and ED, EF fall on BA, BC, we can prove that

$$AB : DE :: BC : EF.$$

Hence,

$$BC : EF = CA : FD = AB : DE.$$

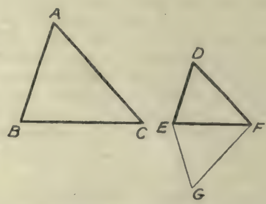
Proposition 57. Theorem

If two triangles have their sides proportional, when taken in order, the triangles are equiangular, those angles being equal which are opposite to corresponding sides.

Let ABC, DEF be two $\triangle$s, in which

$$BC : EF = CA : FD = AB : DE.$$

It is required to prove that $\triangle$s ABC, DEF are equiangular.



Proof. At E, in EF, make $\angle FEG = \angle B$. At F, make $\angle EFG = \angle C$. Then

$\angle G = \angle A$ (*Prop.* 14).

$\therefore AB : GE :: BC : EF$ (*Prop.* 56).

But $AB : DE :: BC : EF$ (*Hyp.*).

$\therefore GE = DE.$

Similarly, it may be proved that $GF = DF$.

$\therefore \triangle DEF = \triangle GEF$ (*Prop.* 7).

But $\triangle GEF$ is equiangular to $\triangle ABC$.

$\therefore \triangle$s ABC, DEF are equiangular.

Definition. Two rectilineal figures are said to be *similar* when the angles of the one, taken in order, are equal respectively to the angles of the other, taken in order, and when the ratio of each side of the one to the corresponding side of the other is the same.

Thus, *similar* figures are figures which have the *same shape*. Note that *two* conditions are necessary for figures to be similar. In the case of triangles, however, we see from Props. 56 and 57 that the one condition involves the other; *i.e.*, if $\triangle$s are equiangular they are similar.

Proposition 58. Theorem

If two triangles have one angle of the one equal to one angle of the other, and the sides about these angles proportional, the triangles are similar.

In the figures of Proposition 56 above, let ABC, DEF be two $\triangle$s in which $\angle A = \angle D$ and $AB : AC :: DE : DF$.

It is required to prove the $\triangle$s are similar.

Proof. Place the $\triangle DEF$ on the $\triangle ABC$ so that D falls on A, DE along AB, and DF along AC. Let E′, F′, be the new positions of E, F. Then, since

$AB : AC :: DE : DF,$

$\therefore AB : DE :: AC : DF,$

i.e., $AB : AE' :: AC : AF'.$

$\therefore E'F'$ is $\parallel$ to BC (*Prop.* 53).

$\therefore \angle AE'F' = \angle B$, and $\angle AF'E' = \angle C$ (*Prop.* 12); so that $\triangle AE'F'$; *i.e.*, $\triangle DEF$ is equiangular to $\triangle ABC$.

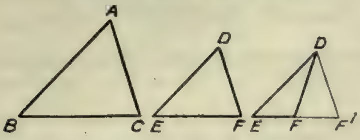
$\therefore \triangle$s ABC, DEF are similar.

Proposition 59. Theorem

If the ratios of two sides of one triangle to two sides of another triangle be equal, and if the angles opposite to one pair of these sides be equal,

then the angles opposite to the other pair are either equal or supplementary.

Let ABC, DEF be two Δs in which AB : AC : : DE : DF and $\angle$B = $\angle$E.



It is required to prove that either $\angle$C = $\angle$F, or $\angle$C + $\angle$F = 2 right $\angle$s.

Proof. (i.) If $\angle$A = $\angle$D, then $\angle$C = $\angle$F and the Δs are equiangular.

(ii.) If $\angle$A is not = $\angle$D, make $\angle$EDF′ = $\angle$A.

Then Δs ABC, DEF′ are equiangular.

$\therefore$ AB : DE : : AC : DF′ (*Prop.* 56).

But AB : DE : : AC : DF (*Hyp.*).

$\therefore$ DF = DF′.

$\therefore$ $\angle$DF′F = $\angle$DFF′.

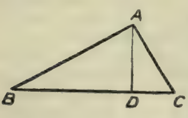
But $\angle$s DFE, DFF′ are supplementary.

$\therefore$ $\angle$s DFE, DF′F are supplementary,

i.e., $\angle$s DFE, ACB are supplementary.

Proposition 60. Theorem

In a right-angled triangle, if a perpendicular be drawn from the right angle to the hypotenuse, the triangles on each side of it are similar to the given triangle and to one another.



Let ABC be a Δ in which $\angle$A is a right $\angle$. Draw AD $\perp$ to BC.

It is required to prove that Δs ABD, ACD are similar to ΔABC and to one another.

Proof. In Δs ABC, ABD, the right $\angle$BAC = the right $\angle$ADB; the $\angle$B is common to both Δs.

$\therefore$ Δs are equiangular, and therefore similar.

In the same way it can be shown that Δs ABC, ACD are similar.

Then, since Δs ABD, ACD are each equiangular to ΔABC, they are equiangular to one another, and therefore similar to one another.

Corollary. Since Δs ABD, ABC are similar,

$\therefore$ DB : BA : : AB : BC.

$\therefore$ AB^2 = BD . BC.

Similarly, from Δs ACD, ABC we get

AC^2 = CD . CB,

and from Δs ABD, ACD

AD^2 = BD . DC.

Thus, *the square on any one of the lines terminating at* A *is equal to the rectangle contained by the two segments which terminate at the other extremity of the line.*

Projection. The foot of the perpendicular drawn from a point to a line is called the *projection* of the point on the line.

If P, Q are the projections of two points A, B on the line CD, the segment PQ is called the projection of AB on CD.

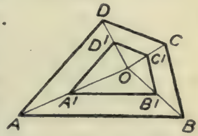
Thus, the first two cases of the above corollary may be worded as follows: *The square on either side of a right-angled triangle is equal to the rectangle contained by the hypotenuse and the projection of that side on the hypotenuse.*

Problems. By the aid of the foregoing propositions it is easy to prove the constructions given in Geometrical Drawing [page 472] for the finding of a fourth, third, and mean proportional to given lines. The construction for dividing a line, internally or externally, in a given ratio is very similar, and should present no difficulty.

Proposition 61. Theorem

If two rectilinear figures are similar, they can be placed so that the lines joining corresponding vertices are concurrent.

Let ABCD and A′B′C′D′ be similar figures.



Then, since $\angle$B = $\angle$B′ they can be placed so that AB, BC are respectively $\parallel$ to A′B′, B′C′.

Since the figures are equiangular, it follows that CD is $\parallel$ to C′D′ and DA is $\parallel$ to D′A′.

It is then required to prove that the lines AA′, BB′ CC′, DD′ meet in the same point.

Proof. Let AA′, BB′ meet in O.

Then, since A′B′ is $\parallel$ to AB

OB′ : OB : : A′B′ : AB (*Prop.* 52).

But A′B′ : AB : : B′C′ : BC (*Hyp.*).

$\therefore$ OB′ : OB : : B′C′ : BC;

i.e., OB′ : B′C′ : : OB : BC.

And $\angle$OB′C′ = $\angle$OBC, since B′C′ is $\parallel$ to BC.

$\therefore$ Δs OB′C′, OBC are similar (*Prop.* 58).

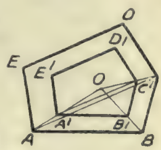
$\therefore$ $\angle$B′OC′ = $\angle$BOC.

$\therefore$ OC′, OC are in the same straight line; *i.e.*, CC′ passes through O.

Similarly, DD′ passes through O.

Proposition 62. Theorem

If two rectilineal figures are similar, their corresponding sides and diagonals are proportional.



Let ABCDE, A′B′C′D′E′ be similar rectilineal figures.

It is required to prove that

AB : A′B′ = AC : A′C′
= AD : A′D′, etc.

Proof. Let the figures be placed so that AA′, BB′, CC′, etc., meet in O (*Prop.* 61).

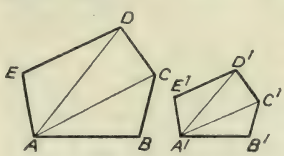
Then, OA : OA′ = OC : OC′ (since each ratio = OB : OB′).

$\therefore$ Δs OAC, OA′C′ are similar (*Prop.* 58).

$\therefore$ AC : A′C′ = OA : OA′
= AB : A′B′.

Similarly, the ratio AD : A′D′, etc., can be proved = AB : A′B′.

Corollary. It follows that: *If two rectilineal figures are similar, the triangle formed by joining any three vertices of the one is similar to the triangle formed by joining the corresponding vertices of the other.*



For AC : A′C′ = CD : C′D′ = DA : D′A′, since each ratio is equal to AB : A′B′.

$\therefore$ the Δs ACD, A′C′D′ are similar.

Continued

Continued from page 5328

CUTLERY

The Manufacture of Penknives, Table Cutlery, Scissors and Razors. Forging, Assembling, Tempering, Hafting and Finishing

By J. H. VINNICOMBE

THE genius of the inventor has not yet superseded the genius of the cutler. Every day we see machinery a rival to the brain and deft fingers of the mechanic; and modern mechanism has not been without its influence in the manufacture of cutlery. But the Sheffield cutler who to-day makes penknives is no more disturbed by thoughts of a machine excelling the cunning of his hands than was his predecessor of two centuries ago.

The ambition of every youth is to possess a knife. As briefly and as plainly as possible we will endeavour to teach him how his knife is made. It should be stated that in the cutlery trade there is a distinction between the "penknife" and the "pocket-knife," although purchasers frequently regard them as different descriptions of the same article. A penknife, as the name suggests, is an instrument which was originally made for cutting "quill" pens, an operation necessitating a fine-cutting edge. A pocket-knife is different, and is constructed to meet those tougher objects which blunt the blade of the more delicate and finely-constructed instrument.

Making a Penknife. The knife which we are about to make with the aid of the apprentice sitting at the bench is one of the simplest patterns, with a single blade. The illustration [1] affords some indication of the processes associated with the making of the blade from the rough piece of steel to its polished state, before it reaches the penknife maker. In front of us are the steel blades, the spring, which will go at the back of the knife, two metal scales, which will enclose the blade, and two pieces of ivory for the covering, or outside scales. Various materials are used for the last-mentioned purpose, such as pearl, ivory, tortoiseshell, stag-horn, and sometimes gold, agate, silver or aluminium, in addition to others. It must be understood that many hands are engaged in the making of a knife; the cutler is the man who fits together the different articles supplied to him. For every knife made there are patterns of the parts, and those which we have to follow we keep well in front of us for the purpose of guidance and for measurement.

1. PARTS OF A PENKNIFE

a. Piece of cast steel from which blade is forged *b.* Mood of blade—first stage *c.* Mood of blade tang, second stage *d.* Smithed blade ready for hardening, third stage *e.* Hardened blade *f.* Tempered blade *g.* Rough ground blade with glazed tang and shoulder *h.* Polished blade—finished *j.* Flied out spring for knife *k.* Hardened and tempered spring for knife

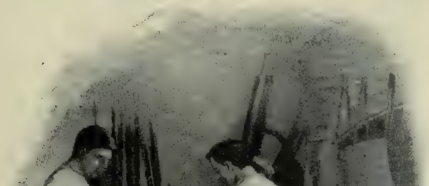
We take the metal scales. At one end of each is what may be described as a *shoulder-piece*. It is fixed to the scale, and will form an important part in the knife because it will hold the blade. It is known as the *bolster*. Its edges are a little ragged when the scales are received by the cutler, and the first process is to "trim the bolster edges," clipping them with shears. Having fixed two temporary pins in the metal scales to keep them together, the next operation is to file the scales according to the pattern or shape of the knife intended to be made. To do this we place a scale on each side of the steel pattern, put them into a vice, and file away the edges until the proper size and shape are attained. There is not much waste, as in giving out the pieces the manager is careful to see that they are as near the size of the pattern as possible. Having made the scales the required size, we take a drill and bore the rivet-holes, not much larger than the eyes of some needles. Through these will pass the small pins for holding the ivory covering, which we match to the scales and fasten them together. Now, instead of the four pieces of material being separate, they are joined so that we have the two coverings for each side of the blade—the ivory being outside, with the layer of brass as the inside lining. We next bore two holes through these two parts, and into these the pins will be inserted to hold the spring, which will form the back of the knife.

Preparing the Parts. Attention is next devoted to the ivory covering, which we find is not the exact shape of the metal lining, so it is filed down until the two are in perfect agreement according to the pattern. The steel spring, which will play such an important part in the movement of the blade, is, perhaps, not quite flat, so this is hammered a little until it is level. We next mark on the spring the two places for the two holes to correspond with those on the outer covering. The necessity for accuracy will be apparent here, otherwise the parts will not fit. The holes through the ivory and metal scales have been made by the use of a hand drill; to penetrate the steel spring it is necessary to go to a drilling machine. The operation is soon completed, and we return to the bench and file the inside of the spring in order to make it work smoothly, and cut it by means of a proper tool to the proper length. It may be presumed that the intention is to make a dozen penknives, because the boy will usually work on this number, and not go straight through and complete one knife before he begins another. Now we bunch twelve springs together and attach them to a wire in order to harden and temper them. We first make them hot in a hearth fire, next plunge them into water, and then, having dried them, cover them with oil, which is made to blaze. This process at an end, the springs are brought again to the bench, and one is selected which is intended for our knife, and this is made perfectly straight by the use of a hammer. Then

we place it on an emery wheel, which, revolving at a great speed, does the glazing and imparts that bright appearance to the inside of the spring which may be observed on opening the blades of a knife.

Hafting the Penknife. After all this preparation an important step is taken in the building up of the knife by placing the spring in its proper position between the scales. We have already referred to the drilling of two holes for this purpose, and very little time is required to pass German wire through the ivory, the metal scales, and the spring. The parts are thus pinned together. We now see the handle of the knife before us, and the next question naturally relates to the blade. Everyone will have observed the bottom portion of the blade by which it is held to the handle. This is known as the *tang*, while that part at the top of the handle which holds the blade and is fixed to the metal scale is known as the *bolster*. We have a pattern for the blade, from which is learnt the proper place for the hole in order to pin it to the handle. Having roughly ground the blade we make another visit to the drilling machine and bore a hole through the tang; and now follows an important operation—it is known as *squaring the blade joint*. Taking our blade, we file the joint at the bottom, making it agree exactly with the pattern in order that it may fit into the bolster. Having burnished the tang, and thus removed any roughness on the sides, the blade is ready to be fixed to the bolster. We have already made the hole, and having put the blade into position, we run a piece of iron wire through it, and the blade is riveted to the handle. The appearance of the rivet on the bolster would be regarded as a disfigurement, so it is filed down, and the top spread until it becomes a part of the bolster, and cannot be seen by the eye.

Finishing Processes. We have now travelled a good way towards making the penknife, and having got the blade into the handle,



2. DOUBLE-HAND FORGING CARVING KNIVES

we move it in order to see whether it is in true position. A little filing may be necessary to make it work accurately. This is known as *jointing the blade*. So far as the construction of our penknife is concerned, it is now practically completed; but there are a number of processes yet to be followed before it has that finished appearance which appeals to the eye. We file the back of the spring, and afterwards put the back of the knife on the emery wheel, and the outside of the spring is roughly glazed. Then we put it on a finer wheel, and the operation of *fine glazing* is performed.

3. MACHINE FORGING TABLE KNIVES

The exterior of the spring is now getting like a mirror with the brightness that is being imparted to it. The knife is next fixed in a wooden clasp, and placed in a vice, so that the ivory handle may be filed and made smooth prior to the polishing; then we file the bolster, afterwards glazing it as we did the spring back, first giving it the rough glaze. Finishing touches are next given to the ivory by rough buffing on the wheel; all scratches and marks are in this way removed. Then we give the fine glaze to the bolster, and this is followed by the fine buffing of the ivory. Various wheels are used for these different processes in order to get the desired results. Then the knife is placed in the vice, and the back of the spring receives its final shine by being burnished with a steel burnisher. The next process is to place the bolster on a polishing wheel, and by the use of the proper material the requisite brightness is given to it. We then wipe the knife to make it clean, and our task is completed. Great care is exercised in order that the handle shall not be soiled, and the ivory is covered with paper. After having been whetted, or sharpened, the oil and dirt will be wiped off to prevent rust.

Large Pocket-Knives. The large pocket-knives, as already indicated, are for rougher work than that for which the penknife is designed, and in their construction the delicate treatment to which reference has been made is not required. In the pocket-knife shop the boy will not be set at first to build up a knife. He will be required to do different tasks necessary to the parts; it may be to straighten the springs, or drill the holes; but by degrees he learns how to construct a knife. It is, however, in the penknife that the genius of the cutler is revealed. Unfortunately, the demand for cheap articles has led to inferior articles of cutlery being offered for sale. This is really bad for the cutler and the customer.

Table Knives and Forks. Without an insight into the manufacture of cutlery it is difficult to imagine the number of processes

associated with the making of a knife. It has been computed that in the putting together and finishing-off of a plain, four-bladed penknife, after all the different parts have been made ready for the cutler, 154 operations have to be gone through. It is now intended to describe the making

4. HARDENING AND TEMPERING TABLE KNIVES

of table cutlery, in which there are different trades associated. We may cite three as the chief—namely, forging, grinding, and hafting, and at once proceed to deal with these, and follow the operations in the manufacture of a table knife.

Forging Table Knives. We first proceed to the forging shop [2], and there observe the hearth fire, anvil, striking tools, and rods of steel placed against the walls. Needless to say, the quality of the steel is of the first importance. The brightness of the blade and the artistic character of the ornamentation of the knife will contribute little to the quality of the cutlery if the steel be poor. The steel reaches the forging shop in long rods, which have been rolled to various shapes and sizes according to the purposes for which they will be required.

Proceeding to make a table knife, the forger will take a bar of steel and place the end into the hearth fire. We watch him work the bellows with his left hand, while at times he withdraws the steel from the hearth. The casual spectator would not appreciate the judgment required in this operation. The skilful forger understands exactly when to withdraw the steel and place it on the anvil. The steel, yielding to successive strokes, gradually assumes the rough shape of the blade, or *mood*, as it is called in the trade. This is now cut off from the bar of steel at the proper length according to the size of the blade required, the forger having a measure on his anvil as a gauge. The blade is then welded to a piece of iron, from which the bolster and the tang will be produced. In table cutlery the bolster may be described as the raised part at the bottom of the blade near the handle, while the tang is drawn out, and is that portion which is fitted into the handle. It is made by a few blows given to the iron as it rests on the anvil, the bolster being formed by hammering the red-hot iron in a *print*, which gives the shape desired. The blade is then heated a second time. On being withdrawn it is hammered more into shape, and the "smithing" process takes place, the hammering giving toughness and strength to the blade. The name and trade mark of the firm are then stamped upon it. Figure **3** shows the process of machine forging, the machine being a power-hammer.

Hardening and Tempering. Now follow the important operations of hardening and tempering the steel [**4**]. The blade is raised to a cherry-red heat, and on being taken from the fire it is plunged into water. It is now hard, but as brittle as glass, and would break if it were allowed to fall to the ground. Tempering is required, and this process demands no little experience and judgment on the part of the forger. After being made red hot and plunged into the water as already described, the blade has a grey-white colour. The workman now puts it into the fire again, and the blade changes first to straw colour, next to mottled brown, and purple, then dark blue, and finally light blue. The different degrees of tempering, which follow rapidly upon one another, have to be closely watched by the forger, who has been taught by years of experience to understand the different qualities of steel and the point at which a blade must be withdrawn from the fire. It may be explained that the stage of tempering depends upon the article, and the use to which it will be applied when finished. For instance, the carving and table knives are taken to the light blue hue; the strong pocket-knife, which will be used for some rough work probably, to the dark blue; a fine penknife to a point between straw colour and brown; and the razor blade, which receives the keenest edge of all cutlery instruments, is withdrawn at the straw colour.

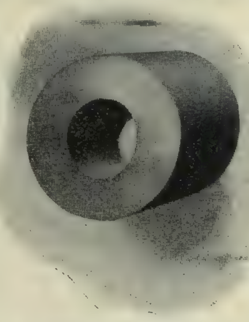
Having withdrawn the blade to be used for the table knife, with its light blue tint, from the hearth, the forger again plunges it into water, and in this way proper flexibility is imparted to it. At some works there is machine as well as hand forging of table blades. When machinery is used, the making of the bolster and the tang and the hardening and tempering are separate processes carried out subsequently.

5. GRINDING AND GLAZING CARVING KNIVES

Grinding and Polishing. The forger has now completed his task, and the blade is ready for the grinder [**5**]. The grinding wheel, or *hull*, as it is usually called in Sheffield, makes an interesting picture. Speaking is carried on only with difficulty amid the hum of machinery and the noise of blades being applied to quickly-revolving wheels. We see the grinders sitting astride their "horses," and watch the pyrotechnic display as steel and stone come in contact. The grinders are at work on different kinds of stones. First we see the blade applied to the rough stone. This runs in

a trough with water up to the surface of the stone, keeping it cool and preventing the heating of the blade, which is placed on a flat stick hollowed out for the bolster. Bending over the stone, the grinder puts sufficient weight on the blade to remove the rough surface. It next receives a finer surface by being placed on the "whitening" stone, which is smoother and harder than that on which the first grinding process took place. The blade is next rough glazed, and then fine glazed upon a wheel dressed with a combination of emery, beeswax, etc. By this process the marks left by the grinding stones are removed. The final polish is produced by "buffing." This is obtained by passing the blade over a wheel covered with thick leather, dressed with superfine flour emery, with the surface thinly covered with beeswax and suet. The last operation being completed, the blade is ready for the hafter, who will fit it with a handle.

Hafting Table Cutlery. In the hafting shop we see fine drills, small wheels, somewhat similar to those which we observed in the pen-knife department, and delicate files. All these are used either for treating the blade or for preparing the ivory for the handle. The tang is straightened, then the bolster is levelled and filed. The glazing of the back of the blade and bolster follows, after which the bolster is passed over a fine stone wheel and the hollow portion is ground. Subsequently this is fine glazed and polished. Attention is now devoted to the tang, which is also glazed. Then follow various processes associated with the preparation of the ivory handle before the tang is inserted. There is the turning of the head of the handle, the rough and smooth filing of the ivory, called *floting* and *single cutting*, the drilling of the hole into the ivory, a difficult operation requiring much practice in order that the drill shall do its work properly. The handle is then made finer by the use of what is called a *shaving* knife, which takes out all the file marks of the single-cut file, after which it is rough buffed by being passed over a specially prepared wheel, called a *sandbuff*, which revolves rapidly, and next it is fine buffed. The matching of the handle to the blade in order to see that it will fit properly follows. Everything being in order for inserting the tang, resin is taken from a small utensil which is kept on a fire, and with this the tang is "cemented" to the handle. Sometimes the tang will go right through the handle with a rivet at the end. This is called a *through-tang* knife. Others will be pinned at the side, and are called *edge-pinned.* The handle will subsequently undergo another buffing process, after which there will be the "dollying," which means placing the handle against a rapidly revolving wheel made of calico. This operation gives to it a shiny appearance. The back of the blade is then burnished, after which the surface is drawn over a very fine "buff," giving it the final polish. It is then "whetted," wiped, and wrapped up for the customer.



7. EMERY CYLINDER FOR GRINDING RAZORS

Making Forks. In the making of nickel silver table forks, which are now so generally used, machinery plays a great part. This can be easily imagined when it is seen that the fork is formed of one piece of material. The metal having been cut into strips of the necessary width, they are then rolled, one end of the fork being required thinner than the other. From these strips the forks are cut out by a machine, and stamped in steel dies to the particular pattern required. The prongs are next "flied" out, after which they are made to assume a neater appearance by a stamping machine. The fork is then filed and bent into the proper shape, and the article receives the impression of the name of the firm, and the trade mark. Having been filed in the rough, the buffing process is carried out, and in this work women and girls are largely employed, the forks being passed over leather wheels dressed with sand and oil. The forks are now ready for plating, a process carried out in the electroplating department. They are afterwards burnished, and then finished on a calico "dolly" dressed with oil and lime, and subsequently they receive a brighter appearance from a finer "dolly," after which they are wiped and sent to the warehouse.

6. PUTTING SCISSORS TOGETHER

Scissors. The forging operation in the making of scissors is most important, and it is only after years of experience that a man becomes a skilled craftsman. The forger of scissors has a shop which resembles closely that of the knife forger; but their operations are quite dissimilar. The former makes the blades, and also the bows, and, although in a rough state, the scissors are complete, so far as shape is concerned, when they leave his hands. The forger first heats the end of the bar of steel, and having withdrawn it from the fire brings his hammer into action, and shapes the blade, which he severs from the bar, leaving sufficient for the shank and the bow.

He will now "set out" the shank by a few strokes of his hammer, and then, placing it against the point of a small anvil, punch a small hole, which later he will increase in size for the bow. The steel is again heated, and the next operation is hammering out the blade. This is followed by the setting out of the joint, an important part of the work, because this

is where the hole for the screw will be bored, and care has to be exercised in making the joint in order that the blades may pair harmoniously. This having been accomplished, there is next the smithing of the blade, which we see gradually assume its proper shape under the strokes of the hammer. Once more the steel is returned to the fire, and the next movement is towards the formation of the bow. We have already referred to the small hole which has been punched; by skilfully hammering the steel on a tool which the forger has on his bench he increases it to the proper size.

Making Large Scissors. So far we have dealt with an ordinary pair of scissors; the larger sizes are treated differently in the forging process. The large bows are not punched in the manner just described. The steel having been heated for the blade, or "mood," it is welded to a piece of iron, which is afterwards drawn out, and later on, after the smithing of the blade, we appreciate the skill of the forger as he curls the iron in the shape of a large bow, and uses his hammer with such dexterity that it is impossible to see where the bow begins or ends. The scissors, in their rough state, and not yet put together, are now taken to a shop for filing. Next they go to be bored, hardened, and tempered, and then to the grinding wheel, where the blades are ground. From the grinder they go to be filed and burnished. The scissors are next taken to the "putter together," as he is known in the trade. He makes the screw that will join the blades. The hole into which the screw is inserted may be described as being of three sizes. It is largest at the top, for the head of the screw, which will be level with the side of the scissor blade. The middle of the hole is smaller, but sufficiently large to allow the screw to work freely, while the size of the hole in the under blade will be only large enough to permit the screw to fit tightly. The scissors-maker or "putter together" has to see that their blades will do their work efficiently. With the use of his hammer he gives the blades the proper curve.

Having fitted the screw, he will take it out and put it carefully into a box, to be used when the blades are finally joined. Each pair of scissors has a distinguishing mark, and the scissors-maker will know the particular screw wanted for each when a large number of blades are subsequently returned to him. When he has made them fit properly, they go again to the grinder, and the blades and shanks are put on a finishing wheel, after which the bows are burnished with a burnishing iron, young women being frequently employed for the latter operation. Now, almost as bright as silver, they are returned to the scissors-maker, who puts them together [6] with the screw that he has already made and satisfies himself that they are perfect.

Razors. The hollow-ground razor has grown into popularity, and in the production of this the grinder plays an important part. Two qualities are claimed for this kind of razor. First, the hollow-grinding gives an edge so thin and so broad that it can be frequently whetted upon an oilstone without requiring to be reground; and secondly, the thinness tends to the lightness of the razor. In the case of the ordinary flat-ground razor, after being whetted a few times, it has to be sent to the grinder again.

The grinder, having received the blades from the forger, proceeds to shape the tang on a dry stone. He also gives the point of the razor its proper shape, making it either round or square. The tangs are then put into the fire, and after having been taken out and allowed to cool, they are given to the file cutter, who makes the indentations on the underside of the blade. This enables a better grip to be obtained by the person who is shaving.

8. HOLLOW-GRINDING RAZORS

The grinding processes now begin. After the blade has received an edge, the hollow-grinding of the blade lengthwise is proceeded with. It is placed on a stone in which have been cut deep grooves. Next follows the process of cross hollow-grinding from back to edge, and this work is performed on very small stones [7]. After this process [8] there is the glazing and the polishing of the tang.

Hafting Razors. Proceeding to enclose the blade in an ivory handle the hafter will receive scales cut to the required length. These he will put to a plate, which is his guide as to pattern. By filing the edges of the ivory, he secures the proper shape, and then, with a fine, single-cut file, he will remove any roughness on the face of the ivory, and afterwards, with a shaving knife, take away the marks that are left by the operation. The ivory will next be buffed on a leather wheel dressed with bathbrick and oil. The scales are now ready to allow the small piece of metal to be inserted in the lower part of the handle, just above the point of the blade when it is closed. This is riveted in, filed, and burnished, after which the blade is riveted with wire at the other end. The hafting is then complete, and the razor is whetted and sharpened on special stones.

The illustrations in this article are from photographs of the works of Messrs. Thomas Turner & Co., and Messrs. Joseph Rodgers & Sons, Sheffield.

Continued

GLOVE MANUFACTURE

Centres of Glove-making. Varieties of Gloves. Tools and Materials. Preparing the Leather. Cutting Out. Sewing. Finishing

Continued from page 5342

By W. S. MURPHY

THE chief centres of glove-making in England are London, Worcester, Leominster, Woodstock, Yeovil, and Ludlow. Up till near the close of the nineteenth century the factory system took little hold on leather glove manufacture, and at Woodstock and Worcester the hand worker still keeps a firm grip of the trade. Glove-making by hand is a home industry. The master glover of Worcester, for instance, gives out the leather and the orders to the workers, who take them home, it may be in a village five or six miles away, and there, father, mother, or children, make the gloves. When finished, the work is brought back to Worcester. At Woodstock, where a special kind of doeskin glove is made, the system is different. But glove-making is there also a home industry, and one may see the tawed leather hanging in the back gardens of the workers.

Varieties of Gloves. Dress kid gloves are the most common form of glove. These are made in many colours and of qualities ranging in retail value from 1s. 6d. per pair up to 7s. 6d., or over. The best qualities are plain, coming only to the wrist, and consist of real kid. Lower qualities are made to resemble kid, the finer class from lambskins, and the rest from sheepskins.

The long-armed gloves which came over from France in Charles II.'s reign have flickered in and out of fashion ever since, and are made in considerable quantities at all times. But the length varies greatly. In general, it may be said that there are three lengths—above the wrist, up to the elbow, and midway up the biceps, the extension being generally, though not always, regulated by the shortness of the dress sleeve.

21. LEATHER WASHING

Gauntlets are a form of glove almost constantly in demand as riding gloves by ladies. The cuff springs out wide at the wrist, and is stiffened either by padding or cane facings. They are made in all kinds of leathers, but more commonly in the heavier classes. Suède gloves are made of skins with the flesh side outward, giving a soft surface.

Doeskin gloves are probably the most durable of fine gloves, very pleasant to the hands, and yet capable of standing rough wear. Many golfers, riders, hunters, and other sports lovers of both sexes, find them very useful. The skin of the deer, from which real doeskins are made, is at once soft and unstretchable; the form of the glove is retained through long wear.

Strong leather gloves are useful to drivers, fishers, and other outdoor workers. Gentlemen favour the lighter kinds of leather gloves for everyday wear, the kid glove being too light.

These are the leading kinds of glove; but we can hardly say that the catalogue of gloves is more than suggested by our selection. Every season a new kind catches the public fancy, or fashion leads back to a style we had thought gone out and passed away. Perhaps, however, it is our duty to hint that the differences are more apparent than real and intentional. For this the factory is chiefly responsible, and the factory worker simply goes on following the patterns.

Tools and Materials. As we have hinted, the home workshop bears a strong resemblance to the factory; the latter is practically the former on a large scale, with the necessary application of power-driven machinery. Some home workers are only glove sewers; but the real glover carries through every process of the operation, from the rough leather to the finished glove. He has, therefore, washing-tub, dyeing trays, staking blocks and tools, paring and doling knives, and tawing materials, such as we have already described in the section on Leather Dressing [pages 3163-6]. The tools of the handicraft glove sewer are few and simple. First are the needles, and these are of the very finest description, glovers' needles being of a special make. Next is the cutting stamp. Machine manufacturers, always on the alert for new trade, have managed to introduce that handy appliance, the stamp cutter, into even the small workshops, with large saving of time. Hand-blocks of various sizes and many models are used. The most ingenious block we have ever seen is the mechanically adjustable model, which can be made any size at the will of the operator. Sewing clamps are indispensable. Unlike the clamps of the saddler and the shoemaker, these clamps have very fine teeth, which

clamp the work and afford a series of regular channels for the stitches. Here, also, we have the ubiquitous sewing machine, now running the hand sewer out of the factory. Besides, we use knives, scissors, hand punches, and other small tools. Last to be used, but not the least important, is the glovers' press. It is by means of this tool the fine shape and gloss are imparted to gloves. The wearing quality is not in the very slightest degree enhanced, but the buyers' eye is pleased.

Materials. The threads of the glover are composed of silk, cotton, and linen. For the highest qualities of gloves, silk is indispensable; heavy gloves are sewn with the linen thread; the most common thread is fine cotton.

Leather is, of course, the material out of which leather gloves are made; but under the term we find a wide range of materials belonging to very different classes. Most of the smaller quadrupeds give their skins to the glove-makers; but the material commonly used consists of the skins of kid, goat, chevrette, reindeer, sheep, calf, and colt. The finest and thinnest gloves are made from kid skins, derived from Switzerland and the mountainous districts of France, Saxony, and Austria. From South America, also, supplies of good kid skins are imported, as well as large quantities of sheep skins. Sheep and lamb skins are imported mostly from Russia, South Africa, Italy, Spain, Hungary, and the Balkan provinces.

22. LEATHER STAINING

Linings. Winter gloves are lined with various materials. The favourite lining is silk, and this must be of the best quality. A very fine flannel is used for men's and driving gloves. Padded, fur-lined, and various other kinds of gloves have been introduced for winter wear; but these mentioned are really the staple kinds.

Trimmings. Of trimmings and fastenings the glover has a constant change, fickle fashion being the dictator in that department. At one time, the cuffs of a dainty gauntlet have to be embroidered in brocade style; at another, silk of one colour runs in lines or curves round the wrists. The backs of the hands are embroidered or plain, in accordance with the fancy.

Fastenings. In fastenings, too, the fashions vary amazingly. Plain pearl buttons, embossed gilt, enamelled, or glass buttons, alternately gain favour. Patent spring catches of ingenious character are brought in every season for winter gloves. Some very pretty devices have been introduced for lacing gloves. Lacing hooks, set with pearls, turquoise, bloodstones, and other precious materials, have come and gone into and out of fashion, with silk, gold, hair, and chain laces. But for these the glover has to keep his eyes open and his inventive faculty alive. A new fastener of novel design will sometimes do more to make a business success than any degree of industry.

Leather Preparing. The appliances and methods of the home worker are various, and frequently primitive, though the product is generally of the finest class. In the factory a more uniform system obtains and may be more easily observed. First, the skins are brought to the sorter, whose business it is to classify the skins according to quality. Sorting demands high skill and great care, especially in these days of clever sophistication. Having been sorted, the skins are washed [21]. Soaked in tubs of tepid water, the skins are brought into a soft condition. As yet, the dollying tub has not been brought into the glove factory, and the driving out of the dirt and grease is still performed by the tramping feet of men, who get into the tubs and tread the leather. This operation is illustrated from Messrs. Dent, Allcroft, & Co.'s factory, to which firm we are indebted for the illustrations of this section.

In the washing operation, a considerable proportion of the egg yolk and flour dressing has been taken out, and a new dressing must be applied if the leather is to retain its softness and flexibility. The egg-yolks are made into a paste with flour, water, and a little alum, the dressing being thoroughly worked into the body of the leather.

Dyeing and Staining. Glove leather may be dyed or stained by three or four different methods. We may choose to stain one side by brushing, plunge the whole skin into the dye-bath and colour both sides, or we may wait till the gloves are made and stain them in the finishing process. The two first methods belong to the department of leather preparation, and naturally come under observation here.

Vegetable dyes are used. The dye having been made ready, the skins are stretched out on a leaden table [22], and brushed over with a mordant, generally a simple alkaloid, to make the colour lie. Then the die is brushed on, coating after coating being applied till the required depth of shade has been obtained. Next, a fixer, or striker, is put on, iron liquor being commonly used for tan and dark shades. Rinsed in water, the skin is then hung up in the hot stove to dry.

One side only of the leather is dyed by the brushing process, the aim being to keep the inner side of the glove white.

When both sides are to be coloured, the

plunging method is used. The skins are simply immersed in the dyeing liquor, and worked through till the material has been thoroughly impregnated with the colour. Otherwise, there is little difference in the two operations.

Open air drying is preferred by the glovers who work at home; but the factory drying is done in a large stove in which a current of air is constantly kept going by power-driven fans.

Staking and Paring. Drying has caused the skins to harden and wrinkle. Softened a little with damp sawdust, the skins are broken over the staking knife—a blunt, semi-circular-blade fixed on the bench. Staking smooths the grain side; but the flesh side of the skins is rough. Fixing the skin flesh side upward, the worker takes a "moon-knife," so called from its shape, and carefully pares away the rough parts. This is delicate work, for the knife is keen and the skin is thin.

23. GLOVE PUNCHING

Doling and Sorting. Doling is a shaving operation, applied only to the highest class of fine kid skins. Laying the skin, flesh side upward, on a slab of marble, the operator shaves the leather with a flat blade shaped like a broad chisel, producing a smooth, hard surface.

Some defects in the skins may have been brought into evidence during the foregoing operations, and they are carefully inspected again, and finally classed for glove-making.

Cutting Gloves. A glove seems a thing easy to cut till you try it. Like a great many acts of craftsmanship, it is simple to describe and very difficult to do. A side of leather is first cut into pieces the size required—that is, double the breadth and a little more than the length of the glove to be made. Double over a pair of the pieces, folding the one from left to right, and the other from right to left, leaving a margin on the under half. The part lying undermost is the back of the glove, and is made larger than the front. Divide the top part of the doubled leather into four, the length of the fingers, with three straight cuts. Open out the front, so that it lies flat on the board, and cut from the edge of the fold outward a slightly oval circle. The hole is the thumb socket, and the three cuts have made the fronts and backs of the four fingers of the glove. Gussets are required for both sides of the second and third fingers, and one side of the first and fourth; and the thumb of the glove must also be cut out. Make sure that the colour and texture of the leather is exactly the same as the body of the glove, and cut to size.

By a slightly different method of operation, after being assorted as to quality and size, the skins are transferred to the cutter, who cuts them into oblong pieces of the size required, which are turned over to the puncher [23], who takes two or three pairs at a time, and subjects them to the action of a press carrying a punch corresponding to the size of the gloves to be made, which forms the hand, with all the necessary slits, openings and button-holes. The thumbs and *fourchettes*, or pieces between the fingers, are punched separately.

There are ten different sizes, from $5\frac{1}{4}$ to 8, for ladies' gloves; thirteen, from $7\frac{1}{2}$ to 11, for gentlemen's; and seven, from 5 to $6\frac{1}{2}$ for misses. Each of these sizes has a corresponding plate which serves as guide to the cutter.

Pointing. On the backs of gloves, various forms of ornamental sewing, or tambouring, are wrought. Pointing, as the operation is technically named, is generally done by hand on the backs, before the gloves are sewn. Plain lines of stitching are sometimes preferred by fashion, and these are put in either by hand or by machine. Heavier patterns are tamboured. First, the holes are stamped in the backs with a mallet and point called a preen. Then another worker, sitting at a frame [25], works the threads into the patterns with a crochet hook. A sewing-machine has been invented which imitates the hand tambouring.

24. GLOVE-SEWING BY HAND

Sewing. Glove-makers speak of three kinds of sewing [24]: roundseam, prickseam, and pique. Roundseam is the oldest and highest kind of work. By this method the glove pieces are put together and sewn over the outside edges, forming the round cord familiar to glove wearers. Prickseam is the coarsest and strongest sewing. The two edges of leather are laid together, and a narrow seam made along the

side, the double edge standing out from the glove. Pique is neater though not so strong, the one edge being placed under the other, and only one ply of leather showing.

Sewing. First in point of time, and yet first for excellence, the hand method [**24**] of roundseam is worthy of primary attention. Here comes in our sewing clamp, or "donkey" frame. Adjust the pieces to be sewn neatly together, and with the foot press the clamp, and with needle and thread begin to stitch. In the clamp are very fine teeth, numbering twelve to the inch, and it is between these teeth the needle passes every stitch. Pass the needle through one side and bring it out at the other, making the little ridge to be seen on all fine gloves. The work is tedious and trying, but practice makes even difficult things easy. Two points are especially important in the making of a glove—the insertion of the gussets and the sewing in of the thumbs. If the gussets are uneven, the work is spoiled; if the thumb sits badly, no amount of blocking will put it right. Another very vital part of the glove is the finger-tip. Badly-sewn gloves first begin to show their weakness there.

Before the sewing machine was brought to its present state of perfection no one could make a glove wholly by machine—at least, not a glove that would stand comparison with a hand-made glove. Now, however, the machine-made glove is practically unrecognisable from the product of the hand. Some of the cheaper classes are not put out to compete with the high-class glove, and they are seamed in a style that condemns them at once, generally prickseam, which is suited best for heavy gloves. No glover has any reason to fear the competition of that quality of glove. But the makers of machines, like persistent suitors, would not be denied, and persevered, till a sewing machine was made that could sew gloves in exact imitation of the hand-sewing. These machines are now in use in all the best factories, and require no special skill to work them. The machinist puts the pieces together, and the machine does the rest. A difference between the hand-made and the machine-made glove can, of course, be observed, and it tells in the wear; but the average purchaser must rely on the good faith of the man who sells.

The varieties of glove mentioned are not all sewn or put together in the same way. Even gloves of the same pattern may be constructed differently. Some kid gloves have small diamond gussets set in to allow for the expansion of the fingers, and others have not. Those smaller gussets undoubtedly assist in fitting the glove to the flexure of the hand, and take the strain of movement off the fingers.

Long-armed and lined gloves present no great technical difficulties. The cutting of the long-armed glove is the main part; the sewing is plain and easy. Lining is cut to the same size as the body of the glove, and sewn in with the gussets. The lining of the fingers is simply back and front.

Buttonholing and hemming are points that must be skilfully done on good gloves. The buttonholing is simply the crossover stitch common to all buttonholes; but the hemming of the edge and the sides of the glove is a delicate operation. No stitch must appear on the outside of the glove; every stitch catches the inner skin and holds by it alone.

25. EMBROIDERING OR TAMBOURING THE BACKS OF GLOVES

Dyeing and Finishing. Fine kid gloves are coloured on one side only, for obvious reasons. If not stained in the skin, the glove must be coloured in the finishing.

After the work of sewing has been completed, the glove is blocked—that is, drawn on a wooden block of its size. Carefully fixed, so that not a crease or wrinkle appears, the glove is painted over with the colour, and left to dry. The first coat is absorbed by the leather, which appears almost as white as before. A second coat is applied, and a third. Now we have a solid colour; but it is dull and hard.

The stained glove is gone over with the polishing bone—a rounded piece of hard bone or ivory, which is rubbed on the surface. It lifts off every vestige of superfluous colour and gives the leather a fine, smooth surface.

In the factory we have a different and quicker method. The dyed gloves are pressed at moderate heat and polished in a few moments.

Now the gloves are looking fairly well, but a finishing touch is yet required. Left in that condition, the gloss would leave them after a single day's wear. To fix the gloss, and add a smooth skin, the white of egg is applied with scrupulous care to the whole surface of the leather. When thoroughly dry, we press the gloves, and they are ready for the market.

Continued

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IRRIGATION AND CANALS

Na ural and Artificial Irrigation. Assuan Dam. Considerations in Canal Construction. Types of Canals

By Professor HENRY ROBINSON

IRRIGATION may be defined as the application of water to the purposes of agriculture, either naturally or artificially. The former is dependent upon the rain and the flooding of the land in times of the maximum discharge of rivers. The latter is effected by means of canals and tanks, sometimes supplemented by pumping.

There are two systems of irrigation—*basin* irrigation and *perennial* irrigation. The basin system consists in turning the waters of the rivers on to the land in flood time. In Egypt, the land is divided up into large areas called *basins*, and the water is allowed to remain on them at an average depth of about 5 ft., for about forty days, and it deposits the silt which the water contains, after which it is drained into the river. With perennial irrigation, the land is watered all the year.

Irrigation in Foreign Countries. The storage of water for irrigation purposes has received more attention abroad than in this country. This is mainly due to the fact that in countries like Egypt and India there are very long periods without any rainfall. Egypt, in fact, is a country which is practically without rain, the rainfall in Cairo being on the average only about 1½ inches per annum, so that it is dependent entirely on the River Nile for its supply of water. In this country, however, although the rainfall is more or less capricious, there is, as a rule, sufficient during the year to enable agricultural operations to be carried on without the aid of artificial irrigation, although some soils are benefited by irrigation. Practical irrigation in this country is confined to damming up streams so that the water flows up ditches and floods the adjoining land.

Irrigation in Egypt and India. For irrigation works of great magnitude, India and Egypt afford some of the finest examples. Some idea of the magnitude of these works may be obtained when it is stated that in 1901 the area irrigated in India from Government canals was 20 million acres, and the total length of main canals was 13,000 miles, with 31,000 miles of distributors. In Egypt, the construction of the "barrages" a few miles to the north of Cairo, and in more recent years the dam at Assuan, serve as examples and will be explained later. In India, many storage reservoirs have been constructed for irrigation purposes under the Public Works Department. Some of these are made with concrete or masonry dams, but the majority are made with dams of earthwork, the material being brought from the neighbouring country and consolidated by the native labourers, who bring the materials in small baskets on their heads, and also by the employment of elephants to tread in and consolidate the mass. Some of the finest works in the world are made in this manner. In storing enormous volumes of water thus dealt with, one of the most important parts of the work consists in providing for the escape of the excess water when the basins or reservoirs are full.

Natural Irrigation. All rivers in times of flood carry a great deal of matter in suspension, generally a mixture of alluvial matter and sand. In the upper reaches, the velocity is generally sufficient to carry this forward, but when the river reaches the valleys this suspended matter tends to get deposited, and so the bed of the river is raised above that of the surrounding country, thus facilitating irrigation. The rivers in flood time carrying vast quantities of this suspended matter, or silt, overflow their banks and deposit the silt on the surrounding land. The fertilising properties of this deposit are great, and after the deposit has taken place, the water is run off the land and the crops are sown on it.

On the River Nile in the old days, banks were formed along each side of the river above flood level. At right angles to them other banks were carried dividing the land up. Canals were cut into the river banks during low water; in times of flood the water was carried on to the land by this means, and the suspended matter deposited there. At the end of the flood the water drained off and the crops were sown on the deposited mud. By this system only one crop could be raised each year.

Artificial Irrigation. On the other hand, in the upper reaches of the rivers, the banks are usually higher than the river bed, so that in order to irrigate them (as in Northern India) it is necessary to tap the river in the higher reaches to obtain enough head to command the high levels. The usual method of conveying the water to the land is by means of canals, and they may be divided into two classes—either for irrigation pure and simple, or combined with navigation, to enable the produce of the land to be transported. In designing canals care must be taken to note the geological formation of the country through which the canals have to pass, in order to determine their proper slope to prevent scouring the beds. When the stratum is hard, the slope, of course, is immaterial as far as scour is concerned. When, however, navigation is combined with irrigation, the slope is material, in order to get as small a velocity as is consistent with the successful carrying forward of the silt, which would otherwise deposit and fill up the channel. Also, if the channel is to be navigable, a certain minimum

depth must be allowed for, which is deducted from the quantity required for irrigation purposes. The calculations for arriving at the size of the channel may be made with the formula already given in considering the discharge of rivers. The coefficient N in Kutter's formula is generally taken as 0·025 for this class of work. It has been found, however, that in some canals in India, which had silted, and by this means adjusted themselves into the best form of channel for their particular condition, a discharge of from 20 per cent. to 25 per cent. in excess of that given by the formula had been obtained.

With regard to the minimum velocity to prevent the deposition of silt in Egypt it was found that when the velocity was less than 1·8 ft. per second it would occur. With regard to the maximum velocity (as previously stated), it must depend to some extent on the nature of the bed and banks. In India, 3 ft. a second has been considered to be a safe maximum velocity. When possible, in constructing the canal, the excavated material should closely approximate to the amount necessary for the banks, and this would be the most favourable condition of affairs. Also, when curves have to be resorted to, they must be very flat, in order to prevent bank erosion.

Irrigation in Steep Country. When the slope of the country is steep, falls have to be resorted to in order to keep the gradient within limits. In this case the velocity is greatly increased, and is consequently felt for a considerable way up the canal. It then becomes necessary to protect the beds and banks, and to make them of such material as will resist this increased velocity. The simplest canals in India are called *inundation* canals. Cuts are made from the rivers inland, and are generally run parallel to the fall of the country or river course, the land being watered when the river is in flood. A permanent supply for canals is generally a river carrying a perennial stream, the head of the canal being located high up on its course, so that the water is more or less free from deposits.

This is known as *perennial* irrigation, as the land receives water all the year round. The quantity of water required depends on the area to be irrigated and the nature of the crops. In Upper India 1 cubic ft. per second has been found sufficient to raise food crops on 200 acres. This, however, varies, as is shown by the following data. On the Eastern Jumna Canal, which has given some of the best results in Northern India, the average depth has seldom been less than 2 ft. 6 in., which would mean about 1 cubic ft. per annum for 300 acres. On the Ganges it has been about the same, and on the Agra Canal the average was 5 ft. 6 in. in one year, whereas in the year following it was 4 ft. 6 in., while it exceeded 6 ft. and 7 ft. on some of the tributaries.

In Southern California, for grape crops and fruits of that class, 1 cubic ft. per second will irrigate 500 acres. In Lower Egypt the year is divided into three seasons—séfi, or summer, nili, or flood, and chitawi, or winter.

The summer crops are cotton, rice, sugar-cane, melons and cucumbers. In the flood season maize is grown, which is the staple food of the agricultural population. During winter the crops are wheat, barley, beans, and clover. Many thousands of water-wheels and engines of various kinds are brought into use for irrigation purposes. The summer crop is the most difficult and expensive to raise, and is irrigated from summer canals, which are supplemented in floods by shallow canals that are used only at that time.

To assist summer irrigation barrages have been constructed at the head of the delta to maintain a higher water-level. The position of these barrages is at a point slightly to the north of Cairo, where the Nile divides into two branches, known as the Rosetta and Damietta. The Rosetta barrage is 1,437 ft., and the Damietta 1,709 ft. These are open dams, built across the streams, provided with regulating gates, which are lowered into position by means of chains attached to the gates and worked by crabs.

Assuan Dam. More recently the great work at Assuan, which is familiar to everyone, has been completed, and will be referred to only briefly. This great dam creates a vast reservoir which supplements the discharge of the Nile during the summer months, and is estimated to hold 37,612,000,000 cubic ft., and gives a better supply of water in summer than was available before its construction.

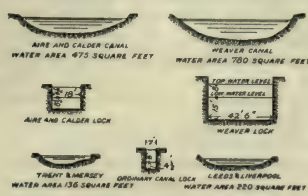
The problem which had to be solved was how to deal with the vast quantities of silt which are brought down by the river in flood, and which would have ultimately filled up the reservoir. This was got over by providing the dam (whose length is about 1¼ miles), with sluices at various levels of sufficient capacity to discharge the whole of the waters in time of flood. These are left open until the water has got sufficiently clear, when they are gradually closed, and the water is then stored.

Indian river weirs are different to the barrages on the Nile, being formed by a solid wall right across the river, pierced by sluices. The barrages in Egypt, which have been mentioned, consist of platforms which are laid across the river, and on which piers are raised and arches thrown over, so that the flood can pass through at its highest level, thus preventing deposits.

Canals. Canals provide the means for transporting goods by boats and barges through inland districts, or of connecting up rivers, and thus opening out great lengths of waterways, as in Russia, France, and other countries. An instance of this is the canal joining the Obi and Yenesi rivers in Siberia, which opens up a waterway of over 3,000 miles by a canal about five miles in length. Since the development of railways in this country, canals have to a great extent been superseded, although those of the Aire and Calder and the Weaver are exceptions. Many years ago the writer converted the Gwendraeth Valley Canal in Carmarthenshire into a railway. This was used for bringing anthracite coal from the collieries in that district to Burry

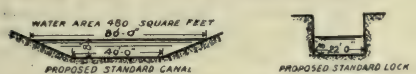
Port for shipment, and for transport by the Great Western Railway, which passes through this district.

Another reason why canals have not succeeded in fulfilling their object to the best purpose is the want of uniformity of gauge of the various canals and locks. This was demonstrated in a paper recently read before the Institution of Civil Engineers by Mr. A. J. Sauer, who exhibited sections of various canals and locks [13], which thoroughly illustrate this point.



13. SECTIONS FOR CANALS AND LOCKS

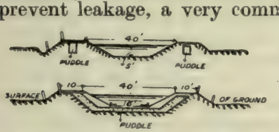
He also suggested that a standard should be adopted of the form illustrated in **14**. The



14. STANDARD FORMS OF CANAL AND LOCK SECTIONS

lock should be 230 ft. in length, as this would accommodate eight of the ordinary narrow boats of 7 ft. in width, with the tug for towing them.

As a canal is essentially a still waterway, it is generally more or less tortuous in its course, in order to follow the contour of the country, and to save great changes in level. When these changes of level, however, are unavoidable, locks, lifts, or inclined planes have to be resorted to. When locks are used—and this is the most general way—if the fall is considerable, the change of level is effected by what are termed *flights of locks*, being a series of locks at different levels. Where the strata is permeable, it becomes necessary to provide some form of lining to prevent leakage, a very common plan being to use clay puddle, although concrete has been employed. Figure **15** shows two typical forms of canals, the lower figure being lined with puddle across the whole section, while the upper one has only a vertical puddle wall, which is usually made about 3 ft. thick, and which is always necessary. Professor Rankine gives the following examples of the extreme and ordinary dimensions of canals.



15. METHOD OF PREVENTING LEAKAGE IN CANALS

—	Breadth at bottom in feet.	Breadth at top water in feet.	Depth of water in feet.
Small canal ..	12	24	4
Ordinary canal ..	25	40	5
Large canal ..	50	110	20

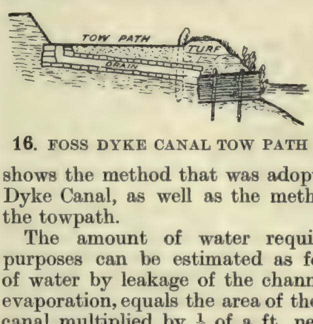
The inland canals in this country afford, as a rule, sufficient depth only for barges drawing from 3 ft. to 5 ft. of water, and the locks provide for boats about 70 ft. in length, and 7 ft. to 15 ft. in width. In the case of the Aire and Calder and Weaver canals, these figures have been greatly exceeded, as the following will show. The maximum size of vessels in the former is 120 ft. × 17 ft. with a draught of 7 ft. 6 in., and in the latter 120 ft. × 25 ft. with a draught of 10 ft. 6 in. The general width of a canal should be sufficient to allow two boats to pass one another, and the depth and sectional area of waterway should be sufficient to cause no increase of the resistance to the motion of the boat other than that due to the water.

Requirements of Canals. The following rules generally satisfy the above:

1. The least breadth at the bottom to be twice the greatest breadth of the boat.
2. The least area of waterway to be six times the greatest midship section of the boat.
3. The bottom of the waterway to be flat, and the sides, when of earth, to be not steeper than $1\frac{1}{2}$ to 1; when of masonry, they may be vertical, but the canal should have about 2 ft. extra width at the bottom.
4. The least depth of waterway should be $1\frac{1}{2}$ ft. greater than the greatest draught of boat.

A towing-path should be provided at one side of the canal, usually about 12 ft. in width at the top, and about 2 ft. above the water-level, and should be made to slope away from the canal, in order to give a better foothold for the horses.

It is necessary to protect the sides of the canal about the water-line on account of the wash, usually about 1 ft. above and 1 ft. below the water-line. This can be accomplished either by pitching, or by fascines of brushwood. Figure **16** shows the method that was adopted at the Foss Dyke Canal, as well as the method of draining the towpath.



16. FOSS DYKE CANAL TOW PATH

The amount of water required for canal purposes can be estimated as follows: Waste of water by leakage of the channel, repairs, and evaporation, equals the area of the surface of the canal multiplied by $\frac{1}{6}$ of a ft. nearly. Current from the higher towards the lower reaches, produced by leakage at the lock gates, represents from 10,000 to 20,000 cubic ft. per day, in ordinary cases. For the expenditure of water in passing boats from one level to another, let L denote a lockful of water—that is, the volume contained in a lock chamber, between the upper and lower water-levels—and B the volume displaced by a boat. Then the volumes of water discharged from the upper pond, at a lock or a flight of locks, under various circumstances are as shown in the table on next page. The minus sign prefixed to a quantity of water denotes that it is displaced from the lock into the upper pond.

Canal Locks. Rankine has deduced from these figures that single locks are more favourable

SINGLE LOCK	LOCK FOUND	WATER DISCHARGED	LOCK LEFT
One boat descending	Empty	$L - B$	Empty
" "	Full	$- B$	
One boat ascending	Empty or full	$L + B$	Full
2n boats, descending and ascending alternately	Descending full Ascending empty	nL	Descending empty Ascending full
Train of n boats descending	Empty	$nL - nB$	Empty
" " "	Full	$(n-1)L - nB$	
Train of n boats ascending	Empty or full	$nL + nB$	Full
Two trains, each of n boats, the first descending, the second ascending	Full	$(2n - 1)L$	Full
Flight of m Locks—			
One boat descending	Empty	$L - B$	Empty
" "	Full	$- B$	
One boat ascending	Empty	$mL + B$	Full
" " "	Full	$L + B$	
Two n boats, descending and ascending alternately	Descending full Ascending empty	mnL	Descending empty Ascending full
Train of n boats descending	Empty	$nL - nB$	Empty
" " "	Full	$(n-1)L - nB$	
Train of n boats ascending	Empty	$(m + n - 1)L + nB$	Full
" " "	Full	$nL + nB$	
Two trains, each of n boats, the first descending, and the second ascending	Full	$(m + 2n - 2)L$	Full

to economy of water than flights of locks; that at a single lock single boats ascending and descending alternately cause less expenditure of water than equal numbers of boats in trains; and that, on the other hand, at a flight of locks, boats in trains cause less expenditure of water than equal numbers of boats ascending and descending alternately. For this reason, when a long flight of locks is unavoidable, it is usual to make it double—that is, to have two similar flights side by side, one for ascending boats, and the other for descending boats. Water may be saved at flights of locks by the aid of side ponds or lateral reservoirs. The use of a side pond is to keep for future use a certain portion of the water that is discharged from a lock, when the locks below it in the flight are full, which water would be wholly discharged into the lower reach. Let a be the horizontal area of a lock chamber, A that of its side pond; then the volume of water so saved is

$$LA \div (A + a).$$

A substitute for flights of locks is the hydraulic lift. One of these was adopted to connect the Weaver with the Trent and Mersey Canal at Anderton, the difference of level being 50 ft. It was capable of raising eight barges up and down in an hour, but the cost of such lifts is very great.

The canal must have a regular supply of water to compensate for losses due to leakage, evaporation, and the water used in the locks. This supply may be obtained from rivers, lakes, or springs, and must be sufficient to tide over times of extreme drought. In some cases the supply is obtained from artificial reservoirs, constructed in the upper reaches of the stream supplying the canal, and providing a storage in flood time for use during dry weather.

Ship Canals. The chief difference between ship canals and ordinary inland canals is in their size, as the former have to accommodate large sea-going vessels. On account of their size and depth they are able to be carried only through country where there is not much change of level, partly on account of the quantity of excavation involved, and partly owing to the necessity of providing locks, with the attendant cost of construction, and the delay caused to the passage of ships through the canal. The object of ship canals may be either to provide a connection between a large town at a short distance from the sea or large tidal river, and a seaport, as, for instance, the Manchester Ship Canal, or by cutting across land to connect two seas, and thus to provide a shorter course for sea-going vessels, as, for instance, the Suez Canal, which connects the Mediterranean and the Red Sea by a canal about 100 miles in length. Narrow necks of low-lying land, intersected by lakes or rivers, afford the best places for constructing ship canals. Ship canals may be divided into four classes, as follows:

1. Canals which, in joining up two seas, traverse high districts involving locks on both sides of the summit, as, for instance, the Caledonian Canal.

2. Canals which pass through low-lying dis-districts, as in Holland, with locks only at the extremities to hold up the water in the canal, at times of low tide, and to prevent the sea entering at high water.

3. Canals joining up two seas without the intervention of locks, as the Suez Canal.

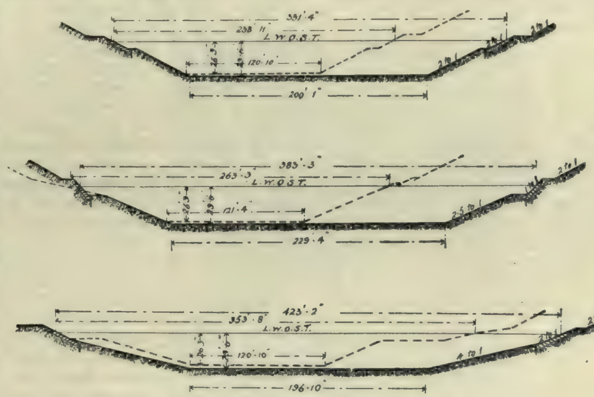
4. Canals providing a direct route from an inland town to the sea, of which the Manchester Canal is an example.

The scope of the present article will enable the writer to deal only briefly with each of these types of canals. He will therefore confine himself to a brief description of one of each class.

High Lock Ship Canals. In ship canals of the first kind—namely, those that have to attain an elevation by means of locks, before descending by similar means—we have the Languedoc Canal in France and the Caledonian Canal in Scotland. The latter, although of very old construction, is, however, typical of this class. It serves the purpose of connecting the east and west coasts of Scotland, through a series of fresh-water lakes—namely, Lochs Ness, Oich, and Lochy. The total length of the canal is about 60 miles, of which about 23 is artificial, the remainder being through the lakes. The artificial portion was made 120 ft. wide at the water level, 50 ft. wide at the bottom, and 20 ft. deep. Regulating locks are provided between the lakes, and sea locks at the entrance at both ends. The total rise to Loch Oich, which is the summit, is about 100 ft. and is accomplished (beginning at the eastern side) with a flight of four locks to Loch Ness, and a further seven, including one flight of five, to Loch Oich. From there it descends by two lochs to Loch Lochy, and then by a flight of eight, and a further two locks, it enters the tidal lock at the western extremity. The locks are about 180 ft. long, by 40 ft. wide, with 8 ft. rise.

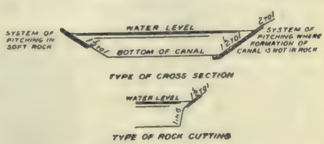
End Lock Ship Canals. Of the second class—namely, those which pass through low-lying districts and connect two seas—the canals of Holland are examples, as, for instance, the Amsterdam Canal. They have locks at their entrances to provide for the variation of tide levels, and are dependent for their water chiefly on the sea. The water-level is approximately the same throughout, being regulated by sluices or locks.

Lockless Canals. An illustration of canals of the third class—namely, for the connection of two seas without the intervention of locks—is the Suez Canal, which connects the Mediterranean and Red Seas. The total length of the canal is 100 miles. Figure **17** shows cross sections at various points. These are taken from a paper by Sir Charles Hartley, and published in the "Proceedings of the Institution of Civil Engineers." In the figures the cross section in dotted lines shows the form of the Canal in 1899, and the full lines that of the proposed ultimate shape. The route chosen for the canal passed through four depressions below sea-level, which are consequently converted into extensive lakes, with an aggregate length of 27 miles. At the same time it was necessary to excavate a certain amount of the whole course, with the exception of some eight miles where the natural depth was greater than that of the channel.



17. SECTIONS OF SUEZ CANAL

Manchester Ship Canal. The Manchester Ship Canal is the example taken for illustrating how an inland town may be served by a canal for the purposes of improving or providing a route to the sea. The length of the canal is 35½ miles, and this connects Manchester with the Mersey, and also opens up the communications with Liverpool. The canal enters the River Mersey at Eastham, about six miles above Liverpool, by means of three locks parallel to one another, and of the following dimensions, 600 ft. by 80 ft., 350 ft. by 50 ft., and 150 ft. by 30ft. These locks maintain a depth of 26 ft. in the canal, subject to certain increases in the tide levels. When extra high tides are experienced, the excess water entering the canal is returned to the river through sluices provided higher up the canal. From this it will be seen that the first part of the canal is semi-tidal, and this is so for the first 21 miles. The locks at Eastham are opened at high tide, and the canal is, therefore, an open cut to the sea. The total rise of the canal above ordinary water-level in the tidal portion is 60 ft. 6 in., and is accomplished by locks in four changes of level, the locks being of two sizes, side by side, and of the following dimensions, 600 ft. by 65 ft., and 350 ft. by 45 ft. The minimum width of the canal at the bottom is 120 ft., and this is increased to 170 ft. at the Manchester end. Figure **18** shows sections of the canal as carried out, and the methods adopted for protecting the banks under varying conditions. Another feature of the canal is carrying the old Bridgwater canal across it on an aqueduct which enables barges to pass over. The limited water supply of the old canal, the loss of water and the time that would have occurred if two sets of locks had been constructed to enable barges to cross the ship canal on its level, as well as the inconvenience to vessels using the larger canal, made it advisable to adopt a movable aqueduct, which was a convenient way of dealing with the crossing of two canals. This was practically an iron trough filled with water, resting on a central pivot, and revolving like a swing bridge, leaving a passage on each side for vessels to pass along the canal. At other times it was closed, enabling the Bridgwater Canal vessels to pass over. The new aqueduct has two movable spans 90 ft. each, with a waterway 19 ft. wide and 6 ft. in depth. It works on a central pier 400 ft. long and 50 ft. wide, which carries also the adjacent road bridge. The pier is mainly built of cement concrete, with brickwork and granite in the part that takes the weight of the aqueduct (1,400 tons) including the water which is always in the iron trough through which the barges pass. The sides of the trough are 1 ft. above the water-level. It is carried by side girders 234 ft. long, 22 ft. 3 in. apart, and 33 ft. deep, tapering off to 28 ft. 9 in. at the ends, with a side tow-path carried on a gallery 9 ft. above the water-level. Water-tight iron swing doors are provided at each fixed shore end, and at each end of the trough. The gates and trough are worked by hydraulic power, and the trough can be swung with the barges in it.



18. SECTION OF MANCHESTER SHIP CANAL

Continued

Group 23
APPLIED BOTANY
9
Continued from page 5313

HOW TO MAKE BASKETS

The Ancient Industry of Basket-making. Cultivation of the Willow. The Tools Employed and their Uses. The Different Kinds of Strokes

PRACTISED as a personal art, each man for his own uses, in the days of rude barbarism, Basket-making very early became a skilled craft, and one of the recognised trades in every small community. At present it is one of the few genuine handicrafts left us by the rapid progress of mechanical invention.

The Scope of the Industry. We speak of the trade as basket-making; but perhaps the more scientific definition would be willow and cane weaving. For the scope of the industry has become very wide. Among baskets there is a large variety—round, square, oval, and flat; laundry baskets, wine baskets, coarse packing, protective casing for fragile ware, such as stone jars or glass carboys, luncheon and tea baskets, chemists' baskets, baskets for fruit, vegetables, provisions and clothes. Fancy baskets, work baskets, and various light forms have come into extensive use, and constitute an important branch of the trade. Closely allied to the fancy kind of basket comes the toy trade, growing every year more important. Doll cradles, chairs, tables, and numerous imitations of household articles, are made to please the childish fancy.

But it is in the larger kinds of wicker-work that British basket-makers have made the greatest advances during recent years. Not only chairs, lounges, travelling hampers, flower-stands, and other such wares, but car bodies for motors, pony carriages, and many large pieces of wicker-work have been successfully made.

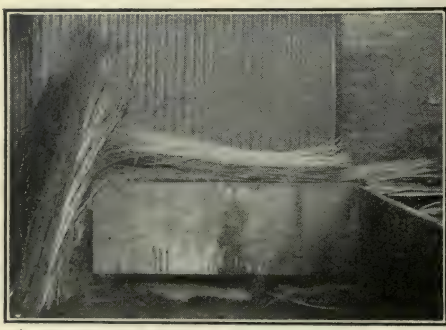
We have mentioned cane along with the willow in attempting to define the trade. Whole cane has been in use for centuries, but it is difficult to work, and requires great strength in the hands to manipulate. In more recent years the introduction of cane-pith, or, as it is sometimes termed, cane - pulp (a material of more facile handling even than willow) has led to a much wider employment of cane products especially among amateur workers. By the skilled basket - maker, cane-pith has come in as a very handy and serviceable addition to his material. It is largely used, often in conjunction with willow, for chairs and luncheon baskets.

The basket-maker uses a considerable variety of raw materials; in addition to willow and cane, rush and straw plait, he takes from the wood-worker many kinds of prepared woods; from the iron-worker, he asks and buys different forms of iron; from other industries he requires various services. But, in the main, the materials of the trade are the willow and the cane.

Willow Culture. Osier farming is a branch of agriculture of which the public hears very little; but, when carried on with skill, and under proper conditions, it is a profitable crop. A special characteristic of the willow family is its fondness for moist, but not marshy nor water-logged alluvial soils. Only very coarse kinds of osier are derived from lowland soils, and the best results are obtained from drained loamy upland soils, well cultivated. The chief species are classified as osier and fine, each subdivided into hundreds of varieties, bearing local names, such as: stone osier, chancellors, red-bud, new-kind, long-bud, Spaniard, French, Pomeranian. The land should be well trenched before planting, and if not subject to alluvial flood, carefully manured. After planting, the osier beds should be hoed over and weeded several times during the year. When this is done, a crop of fine osiers, in normal seasons, is the reward of the cultivator. After cutting, the willows are classed, the finest being peeled, and the coarser kinds, after being well dried in sun and air, stacked in their skins. To produce what are technically named *buffs*, the rods, generally of fine quality, are boiled in their skins before stripping. The tannin of the bark imparts to them a fine buff colour.

Sorting the Willows. The different kinds of willow come to the basket-makers in sorted bundles. Unstripped are called brown, the other two kinds are known as white and buff. Old names still survive in the trade for the different sizes of brown, white, and buff. The method now most commonly adopted is to class them as follows: twig, short small, long small, threepenny, middleboro', and great. The names differ a good deal, but this classification is sufficient for all practical purposes.

The willows are soaked in tanks for a period [1], the length of which is determined by the kind and the purposes for which the material is to be used, and are again more carefully sorted before they are used for the finer kinds of work



1. WATER TROUGHS FOR SOAKING WILLOWS

Cane. Derived from the "rattan" of commerce, many species of which grow profusely in nearly all parts of our Indian Empire, the cane is imported in bundles of 100 each, from 15 to 20 feet long. The finest skeins, made from the flinty epidermis of the cane, are of great length, the tough, woody substance that remains being drawn through cylinders of varying diameters and sold as cane-pulp.. The cost of the material has led to the invention of cheap substitutes, none of which, however, have proved serviceable enough to merit mention.

Cutting Tools. Basket-making, as has been said, is a skilled handicraft; no machinery is employed in the workshop itself. The basket-maker does the whole of his work by the aid of the very simplest tools, of which a kit, supplied by Mr. G. Buck, is shown in **2**. Taking the cutting tools first, we note the shears, K. Shaped like a pair of

strong pincers, with long legs and short blades, the shears give the worker great power, enabling him to cut through fairly strong osiers very easily. Three knives, B, C, and H, are shown, though many basket-makers contrive to get along with one, or, at most, two. The *picking knife*, B, is curiously shaped; straight on the back, the face of the blade slants forward at an angle to the head, which is cut off at an obtuse angle. The *shop knife*, C, is a plain blade, and the smaller knife, H, has a very fine blade, keen and pointed.

Tools for Skein-making. A very important group of tools are those for making skeins, D and E. Made of hard wood, with a round head fitting into the palm of the hand, the body of the *cleave* is wedge-shaped, with grooves running from point to neck. The number of grooves determines the number of parts into which the rod is to be split. If we are to get three skeins, the cleave with three grooves, D, is used; if four skeins are being made, the four-grooved cleave, E, comes into operation. With the knife make the cuts in the top of the willow; the grooves of the cleave are fitted into the splits, and by pushing steadily through to the end you obtain the rough skeins. After being split, the osier or fine skeins have two faults which should be corrected before using. The pith of the heart of the split willow remains on the inner side of the skein; the taper of the natural growth of the wand from butt to tip shows itself in the gradual thinning of the skein. To remove the pith, and make the skein equal in all its length, we have two kinds of tool, the one called the upright, F, and the other the shave, A. In principle, both tools are the same, but in form very different. In the *shave*, the cutting tool is a steel blade placed in a graduated position towards an iron bed. The blade having been set to the thickness required, the skein is drawn through with the right hand, while the left thumb guides it against the blade. In this way the skein is planed, and an equal thickness obtained.

2. TOOLS USED BY BASKET-MAKERS
a. Shave *b*. Picking knife *c* and *h*. Shop knives *d* and *e*. Cleaves *f*. Upright *g*. Awl *j* Iron *k*. Shears *l*. Bodkin *m*. Commander or Dog

The *upright* is rather more ingenious, the cutting tools being contained within a holder. The blades having been set by thumbscrews to the breadth we think the skein will stand from end to end, we draw it through the upright, cutting away irregularities. Now the skeins are ready for any purpose.

Other Appliances. Two round-pointed *bodkins*, L, one long and one short, are required for making openings, either in the thick osier or between the woven work. An *awl*, G, is sometimes added. Resembling closely a broad, strong file, with a round head for handle, the *iron*, J, is useful for driving the work close, or for sending home tightly-fitting stakes.

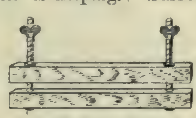
The fitness of the names the basket-maker has applied to his tools comes out vividly in the *commander* or *dog*, M. It is a strong iron rod with two teeth at the one end and a ring at the other. This tool is used for straightening crooked sticks, and other similar purposes.

Closely resembling a horizontal vice, the *screw block* [3] is used for holding the sticks of the covers and bottoms of square baskets. The ends of the sticks, after being *sliped*, are inserted between the blocks, and the screws fix them firmly in position for the worker to weave the rods over them. These tools are made of beechwood, 2 in. square, and from 24 in. to 36 in. long. The threaded bolts of iron are fitted with screws for working with the finger and thumb, or the bodkin.

The basket-maker has his own *yard stick*, generally a wand, marked in inches. In the workshop, we find *the plank*, the *work board*, and other appliances of general use, varying in kind with the styles of work carried on.

Definitions of "Strokes." *Randing* is the weaving of a single rod in and out on the sticks which form what might be called the warp of the basket. *Working a pair* is the weaving of two rods alternately over one another. *Slewing* is working with two or more rods at the same time. The opposite of the pair is the *fitch*, in which two rods are worked under each other. The most complex of the common strokes is the *wale*, three or more rods being woven over and under each other in regular sequence. There are other kinds of basket-weaving, which are shown in the descriptions of the various methods of bordering.

Making a Round Basket. The shortest and simplest way of initiating the beginner into the various strokes is to bring before him a round basket in which they are exemplified. Of course, the apprentice in a basket-making shop is not so quickly given the knowledge of the rudiments of his trade. He has first to find his way about, doing odd jobs of sorting, and making himself generally useful; then he is given small parts to do, under the superintendence of the journeyman whom he is helping. Surrounded by expert workmen, examples of dexterity always coming before his eyes, the apprentice can afford to bide his time.



3. SCREW BLOCK

Suppose, then, we have undertaken to make a strong, large basket of round shape, such as **4**, which is reproduced by permission from the "Journal of the Society of Arts," January 11, 1907.

The Bottom. The first part to be made is the bottom. Cut the butts from, say, six rods, of nearly equal thickness, and the same length, but rather longer than the diameter required. Cross three over three at right angles, slicing a little at the centre where they cross, to let them lie neatly. Prepare two rods, called *slath rods*, and sharpen the ends. The crossed sticks are on the plank, and, pressing them down with the foot, you thrust the sharp end of the first slath rod in at the crossing, bend it round the

three ends pointing away up over the sticks to the right, down round the sticks directed towards you, and up on those to the left. At the same time we are working the other slath rod in an opposite direction, crossing them over one another, binding the whole in one, and forming what is called the *slath*.

The same method is pursued in making the body of the bottom, with a difference. The slath rods have been worked as a pair—that is, two worked alternately over one another—but the bottom sticks have been treated as four units of three. But as soon as the slath has been firmly tied, we begin to open out the sticks, passing the weaving pair in between each, widening them out further and further, so as to form them into radii of a circle the size of the bottom of the proposed basket. When the size is reached, the surplusage of bottom sticks is cut off.

Upsetting. We have now to see about making the sides of the basket. First select an odd number of rods, or stakes, say 23, if the sides are to be *slewed ;* an even number, say 24, if they are to be *randed* or *fitched*. With the shop knife make long points on the stakes by cutting into the backs, and insert by the sides of the bottom sticks. Having driven the sticks well in, prick each one up with the point of the knife. The upper ends of the stakes will be flying loose, and to keep them in position a hoop about the size of the head of the basket designed should be made and put round the upright stakes, holding them up in position. Now drive them in evenly all round with the iron.

The *upset* we now propose making is done by the stroke named the *wale*. This gives a good basis to the basket. Selecting three rods as nearly alike as possible, we weave them alternately one over the other, and in their intertwining enclose the stakes. If the basket is to be *footed*, begin with the tops and piece in three other rods when the butts are worked out. If not footed, begin with the butts, which are sliped and inserted in sequence alongside three following stakes.

Filling. The upset made firm, we may fill up the sides with any or all of the strokes we have mentioned. Suppose it is an open skeleton-sided basket that we have to make. In this case we use the fitch, and bye-stakes are inserted in the upset between the pairs of stakes. This stroke comes as near to simple twining as it is possible to imagine. We begin with two rods ; for short lengths, a single rod is doubled and twined. On the round basket, however, it is better to use two. Rod No. 1 begins behind stake No. 1, and comes round in front of stake No. 2 ; rod No. 2 begins behind stake No. 2 and twines with rod No. 1 as it comes round to pass in front. The one is always passing *under* the other, not above, as in the pair. Two or more fitches are required, according to the depth of the basket, which may be strengthened by a wale above each.

Now we want a strong binding course for the top of our basket, and resort is again made to the wale. If working with three rods, weave them over two stakes and behind one alternately, while making each follow and weave over the other in regular succession. The stakes are then laid down and woven behind and in front of each other to form a border.

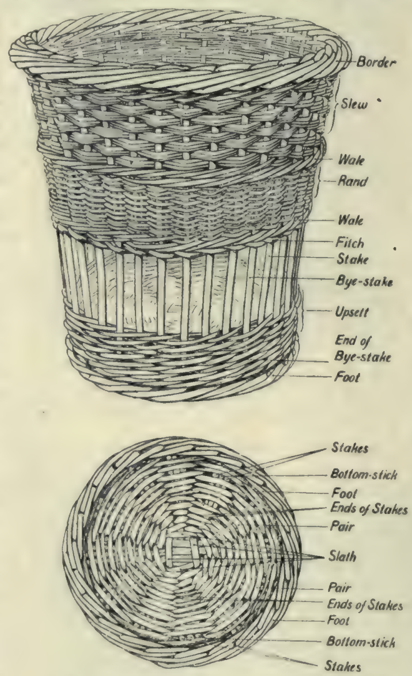
Randing and Slewing. Randing is at once the simplest and most effective weaving. Like plain weaving of cloth, it is the foundation of all other styles. From this it will be inferred that the stroke is simply one rod over and under one stake alternately. Select a rod, put the butt behind a stake, the length of the rod extending to the right, and with a jerk of the finger and thumb draw it in front of the next stake ; then jerk it back behind the next stake. In this simple style weave as much of the side as is necessary.

The quick filler is the *slew*. With this stroke, an expert worker could fill up the sides of a basket in a very short time. The best way for a learner is to start with one rod and gather up to three in the following way : Put one rod in and carry it round a stake or two; put in another to run alongside ; add the third ; then carry the slewing right round, always adding on a rod as one comes to an end. This is the method used in the construction of the coarser kinds of basket-work, such as packing.

The stakes are longer than the sides require by a good deal. With the picking-knife prick each stake on the right side, and bend over from left to right, so as to come close over the last round of weaving Pass each successive stake under the bend of the one before it, and then carry forward over a proportion of stakes, according to the number available and the thickness of the border desired. In passing along the stakes add to the thickness of the outside breadth ; when brought round to the inside again, they add to the breadth of the inside. Thus the stakes are twined into an equal border. The protruding ends are cut off by the picking knife.

The foot, when needed, is worked in similar fashion. The tops cut from the stakes, after the border has been formed, are inserted beside the upsetted stakes. Having been thus fixed, two rounds of waling are added and the foot rods are laid down and worked into an ordinary border.

The lid is generally made like the bottom. Many and complicated methods of handling are practised. The simpler form is to top a rod and sharpen the butt, which is inserted alongside a stake. The rod is then twisted, looped under the border and roped over itself three times, resembling a three-stran'ed rope.



4. THE PARTS OF A BASKET

Continued

Continued from page 5346

SURGICAL INSTRUMENT DEALERS

The sale of surgical appliances can hardly be made into a separate business unless under exceptional circumstances, and in large cities. As a rule, the sections dealt with in the following article are combined with other businesses, such as a chemist and druggist, or herbalist. Some sections are more suited for certain districts, the most important being those dealing with the supply of elastic hosiery and trusses. These are departments of a chemist's business which are often much neglected. The stock required is not large, but it is necessary to have a lady assistant for fitting on ladies' surgical appliances. Often the chemist's wife is available for this purpose, but both qualified and unqualified women chemists are now readily obtainable.

Surgeons' Requirements. These are very numerous, but we have space to refer to them only in general terms. In the first place, sets of operating instruments cost about 12 guineas, but a case of instruments for minor operations, costing about £10, is generally the armamentarium of the general practitioner. Pocket dressing sets cost 30s. to 42s., and are carried by most surgeons. Stethoscopes cost from 2s. 6d. each to 10s. or 15s. for the binaural pattern. Vaccination cases to meet the Local Government requirements cost 15s., although many surgeons content themselves with a lancet and vaccine points without having a special case. Splints are necessarily stocked by those who supply surgeons; these cost from 2s. a set of Gooche's to 4s. 6d. a set of Cline's or Pott's. Pemberton's hand splints cost 4s. 6d. a pair. Fracture-cradles are often let out on hire; they cost from 7s. 6d. to 21s. each, and are charged 2s. 6d. to 5s. for hire. Catheters and bougies and various kinds of syringes are in constant request. Forceps, knives, speculums, and drainage tubes may be mentioned, each of these classes being made in great variety, each for special purposes. Instruments for the ear, eye, mouth, throat, and teeth exist in bewildering variety.

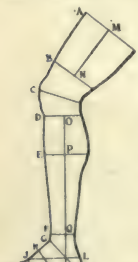
Nursing Requisites. Nurses' chatelaines, to contain such instruments as forceps, spatulas, and clinical thermometers, sell at 15s. complete. Clinical thermometers cost from 12s. a dozen, with lens front 20s. a dozen, and sell at 2s. 0d. to 3s. 6d. If a Kew certificate is supplied, the charge is 1s. 6d. each extra. Bed-pans are either circular or slipper-shaped, and cost—round, 2s. 6d. to 3s. 6d.; slipper, 3s. to 6s. These prices are for earthenware, but for hospital use enamelled iron or block tin pans are demanded. Earthenware urinals cost from 1s. 6d. each; the shapes are known as spoonbill, upright, and coach. Many kinds of brushes are required by nurses for applying pigments to the body. Small camel-hair brushes are designated crow, duck, goose, and swan, according to size. Feeding-cups are made in earthenware and glass, the former being in greatest demand and costing from 10s. a dozen. Earthenware inhalers cost about 2s. 6d. each, and sell at 3s. to 4s. Chest-protectors are much required as the winter season approaches. These are made in scarlet or white felt, pine felt, or rabbit skin. When the protectors cover the back as well as the chest, they are known as lung-protectors. The sizes run from No. 0 to 6, No. 4 being the favourite size. A No. 0 chest-protector measures about 7 in. by 8 in.; a No. 6, 14 in. by 16 in. Spitting-cups are necessary for bronchial patients; the cups cost from 5s. a dozen, but the kind costing 7s. or 8s. a dozen are most usually sold. Bronchitis-kettles sell at 1s. 9d. to 4s. 6d., and cost from 1s. to 2s. 6d., according to size. Bed-baths are less frequently required; they are in form like a slipper bed-pan, but made of tin and deeper. Medicine droppers, tumblers, and spoons are other nursing conveniences that should be mentioned here.

Bandages and Dressings. In this section must first be mentioned lint, cotton-wool, and bandages. Lint, such as is used for surgical dressing, costs 1s. 4d. per lb., but if really made of linen it is more expensive, but hardly worth the extra amount. Cotton-wool in the cheapest qualities costs 8d. per lb., but a pure white absorbent wool, costing 1s. 9d. per lb., is most in demand. The lint and wool are also supplied medicated with sal alembroth, carbolic acid, boric acid, etc., lint thus rendered antiseptic costing about 2s. 6d. per lb., cotton-wool 1s. 3d. per lb., while medicated gauze used for covering costs 1s. 6d. per dozen yards. Surgeons' bandages are made of bleached or unbleached calico, gauze, and flannel, the kind known as water dressing being mostly used. These cost from 1s. per dozen 2-in. bandages. The width of bandages depends on the use to which they are to be put, the narrow ones (1 in.) being for the fingers, the broadest (3 in. to 4 in.) for the thighs. In some cases it is preferable to keep the bandages in rolls of 20 in. wide, and cut to other widths with a sharp knife. Esmark's triangular bandages are much in demand when ambulance classes are being held; these bandages cost 6s. a dozen, and sell at 9d. to 1s. Other bandages are plaster of Paris and stockinette; the former are used to give support in fractures of the limbs, and the plaster sets when wetted with water. Martin's rubber bandages are used for varicose veins of the legs; the cost is from 10s. 6d. each, this being for a bandage 21 ft. long, 2½ in. wide. Suspensory bandages are much used by athletes, and for riding; they are made with cotton or silk pouches, and sell at from 1s. to 3s. 6d. each, a bandage selling at 1s. 6d. being most in demand. First-aid dressings are often carried by cyclists and motorists; they sell at 1s. each. Strapping plaster in yards and rolls is needed for surgeons' trade. The favourite is the brown holland adhesive, which costs 6s. a dozen yards.

India-rubber Goods. The uses of india-rubber for surgical appliances are very numerous, chiefly in those cases where impervious articles are desired. Water-proof and air-proof goods are in great demand. Hot-water bottles are perhaps best known; these run in sizes from 6 in. by 8 in. up to 10 in. by 12 in., the former costing 3s. and the latter 6s., and selling at 4s. 6d. to 8s. 6d. Water-cushions and water-beds are larger forms of the water-bottle. Water-beds are generally let out on hire, and a bed 30 in. by 72 in. costs about £5 10s.,

according to the weight of india-rubber. The hire charge is from 15s. a week, but the bed should not be let out for infectious cases, and in any case must be well washed with carbolic soap when it is returned. Air-pillows, circular, cost about 7s. for a 15 in. size, and 9s. for 18 in.; the reeded pattern, 16 in. by 12 in., 6s. each. Air-beds are often preferred to water-beds on account of their lower cost, an air-bed 24 in. by 72 in. costing about 50s. Ice-bags and ice-caps are in demand, a circular ice-bag 6 in. in diameter selling for 1s. 3d., 12 in. 3s., and costing 9s. and 20s. per dozen respectively. Waterproof sheeting is either single or double, and is 36 in., 60 in., and 72 in. wide. Single sheeting costs 1s. 3d., 2s. 3d., and 2s.9d. a yard, and sells at 2s., 3s., and 4s. a yard. India-rubber urinals for men and women sell at 12s. to 15s. each, but being not much in demand seldom pay to keep in stock. Enema syringes, douche-cans, injection-bottles, spray-producers, breast-exhausters, nipple-shields, and finger-stalls fall into the class of druggists' sundries usually associated with the business of a chemist and druggist.

Elastic Hosiery. Varicose veins in the legs were formerly always treated by bandaging. Now some form of elastic hosiery is nearly always employed. Not only for varicose veins are elastic goods used, but they are used as supports for the ankle after sprains, and for weakness of the knees. Athletes require them for the arms or legs weakened by excessive strain in football, cricket, shooting, or lawn-tennis. The material from which elastic hosiery is woven by machinery consists of india-rubber threads alternated with threads of cotton, silk, or wool, and the articles are made white, pink, or blue tinted, and sometimes red, drab, or black. The various articles are made to draw on or, less frequently, to lace. The former are more convenient, besides being cheaper. For warmth in cases of rheumatism, elastic hosiery is made with a fleece or pile of wool on the inner surface, this especially applying to knee-caps. The following table gives the kinds of elastic hosiery in common use, tells how to measure the patient, and the cost and retail price of each article. The measure is taken on the naked limb on rising in the morning, and an allowance of one in eight is made for pressure by the stocking maker; the patient must give the exact measure. The prices are approximate as the cost varies considerably with different makers, and it is as well to remember that cheap elastic hosiery is not always cheap in the long run. The makers keep some eight or nine stock sizes, numbered 1 to 8 according to the length, a No. 5 stocking being 16 in. long; while the circumference of stock sizes is indicated by letters, a C stocking being about 10½ in. Dealers will find the plaster legs sold by wholesale druggists' sundriesmen at about 5s. very useful for displaying elastic hosiery. The measurements required for wristlets and elbow supports will be judged from what is required for hosiery.



Belts and Braces. Belts are used as supports for the abdomen. The measure must be taken with great care as the belt should fit like a glove. The best guide is a calico pattern fitted to the body. The fronts are made flat or round, and it is necessary to give the circumference at three places, and the depth both at the back and front. Ladies' abdominal belts sell at 7s. 6d. to 21s. Belts of various kinds are made for gentlemen. The knitted variety is known as a cholera belt; while money belts are often asked for by those going abroad. Chest-expanding braces are needed for women and children; they cost from 4s. to 10s. each.

Trusses. There are four kinds of rupture or hernia for which trusses are required: (1) inguinal, (2) scrotal, (3) femoral, and (4) umbilical. The most common rupture is inguinal (in the groin), and it may be either on the right or left side or both sides, requiring single or double trusses, as the case may be. The common kind of truss consists of a steel spring for encircling the body and a pad for pressing on the rupture, the whole being covered with basil and moleskin. The ordinary sizes are 30 in. to 40 in., 36 in. being the size mostly required. These trusses cost from 16s. to 30s. a dozen single, and 30s. to 50s. a dozen double, and sell at from 2s. 6d. each. Other kinds are the Moc-main, S. and O., and Coles pattern. The Moc-main have no springs and are suited for patients who do not have heavy labour to perform. This pattern truss costs 8s. single, and 15s. double, and sells at 12s. 6d. and 21s. In measuring for a truss, a tape measure is used. It is passed round the hips, and the number of inches indicated is the size of truss required. The truss is put on while the patient is laying down. For bathing, trusses are covered with india-rubber, and the pads of the ordinary trusses are made of various materials, such as wood, ivory, or celluloid, and in some cases the pad is filled with glycerin. The scrotal truss has a triangular pad which goes between the legs. The sizes run the same as the inguinal trusses, but they are more expensive, single trusses costing from 4s. each and double trusses 7s. each, selling at from 7s. 6d. each. Femoral trusses for rupture situated in the thigh differ from the inguinal truss in the size and form of the pad and the direction of the thrust. There are two general forms of femoral truss, known as circular and half-spring. The circular form costs from 2s. 6d. each single, and 4s. each double, and sell at 5s. and 8s. each; while the half-spring pattern costs 6s. and 12s. each, the retail price being 8s. and 17s. 6d. each.

Description.	Measures required.		Cost per pair.		Sell at per pair.	
	Circumference at	Length at	Silk.	Cotton.	Silk.	Cotton.
Stocking.. ..	D, E, F, G, H, J	O to K, J to L	8/6 to 9/6	4/9 to 6/-	10/6 to 12/-	6/6 to 7/6
Legging	D, E, F	O to Q	6/6 to 7/6	3/9 to 4/6	8/6 to 9/6	5/6 to 6/-
Sock or Anklet	F, G, H, J	F to K, J to L	4/- to 6/-	3/- to 4/-	5/6 to 7/6	4/- to 5/-
Knee-cap ..	B, C, D	B to C, C to D	5/6 to 6/6	3/3 to 4/-	7/6 to 8/6	4/6 to 5/-
Knee stocking	B, C, D, E, F, G, H	B to D, O to K, J to L	13/6 to 16/6	8/6 to 10/6	18/- to 21/-	10/6 to 12/6
Knee-legging..	B, C, D, E, F	B to D, O to Q	12/6 to 14/-	7/- to 9/-	15/- to 18/-	9/6 to 12/-
Thigh piece ..	A to B	M to N	6/- to 7/6	3/6 to 4/6	8/- to 9/-	5/6 to 6/-
Thigh legging..	A, B, C, D, E, F	M to N, N to O, O to P	15/6 to 21/-	10/- to 13/-	20/- to 23/-	12/6 to 14/6
Thigh stocking	A, B, C, D, E, F, G, H, J	M to N, N to O, O to K, J to L	20/- to 23/6	12/6 to 14/6	25/- to 30/-	16/- to 18/-
Thigh knee-cap	A, B, C, D	A to B, B to C, C to D	11/- to 13/6	6/6 to 8/6	15/- to 18/-	9/- to 10/6

Umbilical rupture occurs in both young children and old persons. Trusses are made for this form of rupture, but the india-rubber or web belts are much better, an air-pad being arranged to press the navel back into its place. The sizes for children are 12 in. to 20 in., costing 1s. 6d. to 2s. each, and retailing at 2s. 6d. to 3s. Another kind of truss—the rectal truss—is needed occasionally for prolapsus ani, such an instrument selling at one-and-a-half guineas, and costing about 20s.

Artificial Limbs and Orthopædic Appliances. The measurement for artificial limbs is a matter of comparison with the size of the corresponding limb. Needless to say, the utmost care has to be taken with the measurements. An artificial leg for amputation above the knee sells at £10 to £15; an artificial arm and hand at about £15. Artificial hands cost from 20s. to 70s. each. Crutches cost from 36s. a doz. pairs, better kinds costing 4s. 6d. to 40s. a pair. Leg-irons for deformed legs sell at four to six guineas. Poroplastic jackets for spinal support cost from 18s. each, the more elaborate Sayre's apparatus costing £5 to £6.

Deafness Appliances. Deaf people require ear-trumpets and conversation tubes. Ear-trumpets in bronzed tin sell at 4s. 6d. to 6s., the telescope form from 7s. 6d. to 12s. Ear-cornets or resonators are a smaller form; they are made bell or egg-shaped. Vulcanite trumpets sell at 5s. to 7s. 6d. Conversation tubes 3 ft. long cost 2s. 6d., and sell at 4s.; but more expensive ones are sold which have ebony mounts and silk-covered tubes. Acoustic fans and audiphones are refinements of hearing apparatus, and sell at from two to three guineas.

SWEET-SELLERS

There is no retail establishment more universally popular than the sweet-shop. Old and young—particularly the young—rich and poor, have the "sweet tooth." It is not surprising, therefore, that shops for the vending of sweetstuffs abound in every district; and the status of the neighbourhood may often be gauged by the appearance of these establishments, and the kind and quality of goods sold therein. It is an enticing trade for people with small capital, for little or no experience is required in learning the business. It is a trade in which, given normal conditions, the cleanly, careful, polite and attentive person is bound to succeed. But it must not be entered haphazard, for there is keen competition in this, as in all other trading concerns nowadays. The grocer, the chemist, the restaurant and the stores all vend sweets of various kinds, and each may be reckoned as a competitor, in some measure at least, to the legitimate sweet-seller. But for a man in delicate health, for a woman who has been "stranded" and does not quite know where to turn in order to gain a livelihood, for a widow, or even for a married woman, who essays to supplement her husband's precarious earnings, the selling of sweets offers a comparatively easy outlet for business energy and enterprise.

Gaining the Necessary Knowledge. The practical confectioner needs no teaching, so that in this article we shall deal only with the sweet-selling novice. It is advisable that, before starting, the beginner—who more often than not is a woman—should get a little practical experience in the treatment of sweets. This may best be obtained in the wholesale depôt of some large manufacturer of good reputation. Such manufacturers are only too willing to give a novice, who is also a potential customer, the benefit of their experience. A week or so in such a depôt will serve to initiate the intelligent pupil into the mysteries of the storage and manipulation of sweets. She will learn very quickly what kinds of goods deteriorate most quickly, how to prevent deterioration, and what to do when the goods show symptoms of becoming stale. It will be impressed upon her that sweets that may have "caught the sun" or have become damp should be made into a "mixture" with other and fresher goods, and sold as quickly as possible at slightly lower prices. Above all things it should be remembered that some goods showing signs of age should be cleared out at once even at a sacrifice of profit; although the best class of chocolates, on the other hand, mature with keeping. Careful storage, cleanliness, politeness, and fresh sweets make a combination that the public will find irresistible.

The Money and the Shop. If the beginner has about £50 capital she may make a very creditable start. Of course, this is a small amount, and the beginning would be humble. A good middle-class neighbourhood, and a small shop with living-rooms attached, would be selected by the young wife or spinster with ambition, taste, and the capital named. The rent in a middle-class suburb would not be great, provided the main street be not selected for the scene of operations. The fittings required for the shop may be quite modest, and need cost next to nothing. A handy husband or male friend could fit up and stain a few shelves around the shop and in the window. A counter, a pair of scales, weights, a scoop, and a gross or two of paper bags of different sizes would not cost more than a few pounds. Neatness, brightness, and, above all, cleanliness, are essential, but the clever woman would find it little trouble to adorn the shelves with fancy paper or other drapery, and so make the place attractive. If feasible, a few glass shelves raised on blocks for the window may be obtained at a small cost, as well as a dozen show-bottles of different sizes, costing an average of 1s. each. Receptacles for the goods are not really necessary, for the manufacturers send out their productions in good bottles and other containers, with attractive labels. These bottles are charged for when sent out, but the charge is credited when the bottles are returned empty. Some manufacturers even supply ornamental cases and dainty show-bottles free on loan to advertise their wares.

Arrangement, Methods and Display. On no consideration need there be a large opening stock. Attraction is the great thing, and taste in window display is the most trustworthy magnet. Small quantities and much variety should be the rule, for in nothing is the public taste so peculiar and varied as in sweets. Therefore, give the public variety, and never let the window be too great a trouble. Let the stock be carefully watched and arranged so that the old is got rid of before the new is begun upon. If in a busy thoroughfare, near a railway station, theatre, or place of amusement, it is essential that packets of sweets be always kept ready to be picked up, for travellers and amusement seekers have not usually much time to waste in fastidious selection. But the chance customer, in the majority of cases, does not make the business. In the environment that we have indicated for our beginner, a family trade should be aimed at. Although apparently a transient business, the sound sweetstuff trade is really not so. It is kept up by regular customers, just as other businesses are, so that the influence of a pleasant and attractive

personality, a bright shop, a fresh and tempting display, and genuine—not cheap—goods cannot be sufficiently emphasised. An endeavour should be made by issuing leaflets, displaying special lines, and so forth, to secure a reputation for selling better caramels, or chocolates, or fondants, or what not, at the same price as competitors. This reputation once established, people will go a long way to get your particular speciality, and they should be made to feel that you are glad to see them. Daintiness—that peculiar attribute of womankind—is even more essential than painful neatness and rigid cleanliness. It is not always necessary to show full packets of sweets, for many manufacturers supply good customers with dummies, and there are plenty of artistic showcards to be obtained free of charge from manufacturers to enliven any spare wall space there may be. Only stock reliable goods, and sell at a fair profit; the "cheap and nasty" trade is not worth the candle.

The First Stock. An expenditure of about £20 would make quite a nice opening display. The aspiring sweet-seller would go, or send, to the showrooms of some reputable manufacturers of general confectionery (like Clarke, Nicholls & Coombs, Ltd., of London, for instance), and select as judiciously as possible a varied stock somewhat on the following lines. In chocolates, order four 2 lb. boxes to sell at 1d. an oz. (cost about 9d. per lb.), two boxes to retail at 1½d. an oz. (1s. per lb. cost), and two boxes at 2d. an oz. (1s. 6d. wholesale). Fancy boxes and baskets should be bought very sparingly at first until the requirements of the neighbourhood are known, and care should be exercised in the purchase of these to make sure that the "turnout" can be sold without loss—that is to say, that a "¼ lb. box" actually contains ¼ lb. of chocolates, and so on. Then select a few of the smallest-sized boxes of popular lines of goods to retail at 6d., 3d., 1d., and ½d. per packet. The cost of such goods is usually 4s. 6d. per gross for halfpenny goods, 8s. 6d. per gross for penny articles, 2s. 3d. per dozen for threepenny goods, and 4s. 6d. per dozen for sixpenny packets. Marzipan selections would be purchased in 2-lb. or 4-lb. boxes in qualities to retail at 1d., 1½d., and 2d. per oz. Then mixtures packed in rows, and loose, other than marzipans will be needed to retail at from 2 oz. for 1½d. to 1½d. per oz. At prices under 2 oz. for 1½d. there are other lines such as gums, fruit pastilles, glacé and crystallised, to be thought of. Then there are popular lines of goods including coco-nut specialities, fondants, dragées and gums to sell at 2 oz. for 1d. For about 21s. ½ cwt. assorted would be secured in bulk. Caramels are perhaps the most popular sweets of all. They may be ordered in 1d., 2d., 3d., 6d., or 1s. packets or loose in 2-lb. or 4-lb. boxes. At least two 2-lb. boxes of approved brands (costing about 9d. per lb.) should be secured. After that ¼ cwt. of boiled drops, toffees, satinettes, fourrés, etc, should be ordered in 2-lb. bottles. These retail from 2 oz. for 1d. to 1d. per oz. Cachous might be obtained in ½-lb. or 1-lb. bottles, but great care should be taken with these. They must be kept dry and in airtight containers, to prevent deterioration, as they are not quick sellers. The retail prices range from 2 oz. for 1d. to 2s. 6d. per lb.; the best qualities retail readily at from 4d. to 6d. per oz. Lastly, a few 4-lb. boxes of lozenges—peppermint, musk, heliotrope, etc.—the products of different makers, would be necessary to complete the stock. It is invariably safe to buy Cadbury's and Fry's chocolates, Rowntree's chocolates and gums, Mackintosh's toffee, Clarnico marzipan selections, caramels and fondants, "My Queen," chocolate nougat and penny marzipans, Peter's and Cailler's Swiss chocolates, and "Devona." These makers have obtained a reputation for the particular kinds of goods named, and there is a public demand for them all over the country.

Making Sweets. In these days of large manufacturers, with up-to-date machinery, it would be ridiculous for the untrained sweet-seller to attempt to make her own goods. If care be taken to deal only with reputable houses, and in approved brands, it will be found much the more profitable and satisfactory method to buy everything from the wholesaler. But some extra-ambitious beginner may have an idea that manufacturing one or two special lines in a small way brings extra credit to the venture. Experience has certainly shown that in some instances kudos is gained by a sweet-seller making a particular toffee or cream of his or her own; but the particular sweetmeat must have some distinction to make it worth the trouble from a pecuniary point of view. If, however, manufacturing is decided upon, a small outfit, costing in all about £5, would include a stove-top, a copper saucepan (to boil 10 lb. or 12 lb. of sugar at a time, a tin frame to pour the toffee into (say, 15 in. long by 10 in. wide and 1 in. deep), a smooth cast-iron pouring plate (3 ft. by 1 ft. 8 in.), for rocks, drops, and hand-cut goods, a pair of scissors and a thermometer. The plate would be fixed on a small table or rough bench, about 2½ ft. high, and there might also be a 3½ in. strong frame and two pairs of rollers to fit.

Sugar Boiling. The process of sugar boiling at different degrees has first to be learned. There are six degrees in sugar boiling, known as the "smooth" (approximately 215° F. by thermometer), the "thread" (230° F.), the "blow" or "feather" (235°F.), the "ball" (240° F.), the "crack" (252° F.), and the "caramel" (260° F.). The "smooth" is tested practically by boiling, for instance, 7 lb. of loaf sugar in 3 pints of water for about 10 minutes after the sugar is all dissolved. Then, if the handle of a teaspoon be dipped, and the boiled sugar drawn between the forefinger and the thumb, and on working it feels slippery, the first or "smooth" degree has been attained. A little longer boiling, and the same test repeated until a thread-like appearance is noted, indicates the second degree. Continued boiling and consequent evaporation gives the "blow" or "feather" stage, which is tested by dipping a skimmer or slice with holes in it into the boil, draining off, and blowing hard through them, until feathery particles pass away. The "ball" stage is only a little in advance of the last, and is known by dipping the boiled sugar on the spoon in cold water and then working with the forefinger and thumb as before. If it is tough, and works like a ball of hot bread, it is at the right stage. When the "crack" degree is reached, and the same test as for "ball" is applied, it will crack. Or if slipped off quickly from the spoon and bitten, the sugar crunches and leaves the teeth without sticking to them. This is, perhaps, the most useful degree in sugar boiling. For the caramel stage, the boiling is continued, and the sugar is watched carefully until it changes colour. The novice will spoil many batches at first, for only practice makes perfect. The foregoing is merely for the guidance of any beginner desiring to experiment, for the business of sugar boiling cannot be taught by books. Moreover, as stated before, it would scarcely be worth the sweet-seller's while. But having gone so far, it might be well to explain how one or two confections are made.

Toffee and Creams. Everton toffee, for instance, varies with different makers; but one of the best methods of making it on a small scale is by boiling 7 lb. of best raw sugar in 3½ pints of water until 245° F. is reached on the thermometer—that is, a stage between the "ball" and the "crack." Then add to the boil 1 lb. of fresh butter, boil the whole nearly to the "crack" over a slow fire, add one teaspoonful of essence of lemon, and pour into the frame. For special purposes, 4 oz. to 8 oz. more butter may be used. Any variety of the soft, rich candies, popularly known as "creams," can be made by boiling together 7 lb. refined sugar, ¼ oz. cream of tartar, and **3** pints of water, to "thread" degree; then take it from the heat and set aside for half an hour. At the end of that time work the syrup with a spatula, or a palette knife, against the sides of the pan until it changes into a thick, creamy-looking substance. When that condition is obtained, mix into it any kind of fruit essence, or fruit preserves, almonds, marmalades, etc., according to the particular variety of "cream" desired. Lastly, put into tin frames or shapes (previously well smeared with salad oil) to set; cut, and turn out when cold. The object of the cream of tartar is to "cut the grain," or prevent re-crystallisation of the sugar. For in the process of sugar boiling the sugar exhibits a strong tendency to crystallise back into its original form, and it will do so when boiled beyond "feather" unless the process is retarded by an acid which prevents the particles being held together by what is known as the "attraction of cohesion." The safest and most trustworthy preventive of this is cream of tartar, in the proportion of not less than ¼ oz. to 7 lb. of sugar.

Expansion. Assuming that the business is growing, and returning a profit, there are many ways in which enterprise may be shown. The fittings may be gradually added to, and show-cases and sweet-stands bought to increase the embellishments of the shop. In this connection, some useful information may be obtained by consulting the articles on Bakers and Confectioners, beginning on page 930 of this section. The stock, of course, would gradually be increased in certain lines as the needs of the neighbourhood are known, but a constant endeavour at a high standard of taste should be made. There is fashion in confectionery as in all else. During recent years, chocolates and caramels of all kinds and shapes have been the rage. Then, the business is affected by the seasons of the year. In spring and summer acid drops and sweets flavoured with the natural juices of fruits are in demand. In the late autumn and winter, nut sweets are asked for, while warming confections, such as those flavoured with ginger or cloves are the thing for cold weather. At Christmas, bon-bons, crackers, Santa Claus stockings, tiny Christmas hampers of chocolates, sugar animals, and so forth, are expected. Easter is a good time for all kinds of white sweets, such as white sugar almonds, white creams, etc., not to mention Easter eggs, which then form nine-tenths of the trade. Aerated waters and ice-cream are appropriate side lines for the sweet-seller, provided there is room for customers to sit down and consume these things. Aerated waters show a good profit, and should be kept in syphons as well as in bottles.

Ice-cream. The ice-cream business, if it can be properly worked, is a very lucrative side line. All that is needed is a freezing machine, made of pewter (which would cost not more than 30s.), a strong wooden tub (large enough to hold the freezer and to admit of the packing of the freezing materials between the sides of the tub and the freezer), and a pewter spatula, or scoop, with a long wooden handle. The mixture to be frozen is poured into the freezer, which is placed in the tub, and the space between filled with broken pieces of ice, and from 2 lb. to 3 lb. of coarse salt. The handle is then turned until the spatula stands upright in the mixture, care being taken during the freezing process to dislodge the "custard" as it thickens from the sides of the freezer with the spatula, so that it may be intimately mixed. The ice-cream "custard" is usually made by whisking four fresh eggs, putting them, with a quart of new milk, ½ lb. of loaf sugar, and 1 oz. of fresh butter, into a pan, whisking the whole together and heating over a slow fire, stirring all the while, until the mixture comes to a boil, when it begins to get thick. Then lift off, strain through a fine horse-hair sieve, or muslin, let it stand till cold, freeze, flavouring with vanilla, and tinging the mixture slightly with saffron to give a "rich" appearance. There are many variants of this recipe, and different flavourings and colourings may be employed, such as raspberry, strawberry, and lemon. Excellent ice-creams are sold ready-made to hotels and shops in small freezers holding about a quart; but care should be taken in such cases to deal only with firms of good repute. It may be that the business increases to such an extent that a pedestal fountain, for the ready production of aerated water, and even the elaborate soda fountain now in vogue, and so popular in America, are looked upon as necessities to supply the wants of the neighbourhood, but that stage of progress would not be reached for some years.

Turnover and Profit. A confectioner must have a good profit, for a variety of reasons. First of all, the hours of business are long, therefore lighting bills are large and attendance is protracted. Moreover, the goods are perishable, and at least 10 per cent. must be allowed all over for deterioration. This is a problem that should be faced boldly from the start, for nothing is more fatal to a business than a reputation for selling stale goods. Therefore, one must be prepared for a 10 per cent. sacrifice on the general turnover. The stock should be turned over at least once a month. The rate of profit on packet goods ranges from 25 to 33 per cent., but on some goods 50 to 75 per cent. on the turnover is no uncommon thing. There is naturally a greater proportional profit on the higher-priced goods, but they have not such a quick turnover. At first, manufacturers or wholesalers would have to be paid cash, but as the business becomes established, a month's credit would be given. The usual trade terms are one month net, but some manufacturers give 1¼ per cent. discount at a month or even considerably more to good customers. Whether a discount is given or not the net cha-ge varies but very little, if at all, among the best firms. Manufacturers are always, of course, willing to aid deserving traders either by longer discounts, or by special prices on special quantities, whenever circumstances warrant such departures from the usual practice. The retail trade is essentially for cash, and this enables the shopkeeper to see how things are going day by day, and to expand or to retrench, as occasion arises. There need be no fear of failure if the trader keep a sharp eye on the condition and requirements of the stock, if she own a dainty and attractive establishment, and if she avoid the brusque and haughty manner, or the careless and slovenly style in dealing with the public.

Continued

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PLASTERING

The Plasterer's Tools and Their Uses. Materials in Plastering. Applying the Plaster. Cornices and Ornamental Work

By Professor R. ELSEY SMITH

THE plasterer's work consists of covering rough and uneven surfaces with a plastic material so as to produce a smooth, hard surface, which may be treated decoratively by covering it with paper or with colour, or which, instead of being finished as a plain surface, may be modelled in relief as a means of decoration.

Plasterer's Tools. The tools used by the plasterer are somewhat numerous, several varieties of some kinds of tools being required in a complete outfit.

A square stand or stance [1] is formed with four legs and with top rails flush with the top of the legs framed all round; a lower set of rails a few inches from the bottom of the legs is required for stiffness, and on these a platform of boards may be formed. This supports the *gauge-board*, on which materials are mixed, which is separate from the stance, and which is usually about 3 ft. 6 in. sq. and ⅞ in. thick: it has two cross pieces at the back and a diagonal piece between them to keep the boards from warping. For gauging concrete these are made about 9 ft. square and 1 in. thick, in two halves, or a temporary platform of scaffold boards is sometimes used.

Brushes [2] for the best quality of work are made of hogs' bristles tied to wooden handles. The stock brush is sometimes made plain and broad; at others, tied up into three or four tufts side by side. Cheaper brushes are made with grass fibre. *Tool brushes* [3] are circular. *Brooms* are made of split whalebone or of wire for keying plaster, etc. *Large compasses* [4] of iron are required, and *calipers* [5] for taking the diameter of convex and concave objects.

Drags [6] are thin steel plates with toothed edges, and vary in size and form.

Floats and Rules. *Rules* and *floats* of various forms and sizes are employed, and should be made of well-seasoned pine, free from knots. The *Darby* [7] has a blade about 3 ft. 6 in. long and 4 in. or 5 in. wide, and has two handles screwed to the back; it is used for floating bays between screeds. A *floating rule* [9] varies from 8 ft. to 20 ft. long, and from 4 in. to 7 in. wide. The back is tapered towards each end; it is used for forming screeds and for forming surfaces between the screeds. A *traversing rule* is a similar rule about 6 ft. long, used for forming screeds in gauged stuff or setting stuff.

A *feather-edge rule* [10] may be made of any requisite size, generally about 5 ft. long and 5 in. wide; it is about 1 in. thick, one edge being splayed to about $\frac{1}{16}$ in. thick. It is used for working and cleaning out angles.

A *gauge rule* [8] is like a straightedge, but has a notch or sinking formed at one or both ends. The double gauge rule is used for forming sunk surfaces, the single gauge for forming raised surfaces. A *parallel rule* is used for levelling and setting out parallel lines; it is made of various sizes, and has its two edges exactly parallel. A *levelling rule* [12] is made by fixing a wood fillet above the lower edge of a long parallel rule, on which a level may be placed for levelling soffits. The *plumb rule* [13] is similar to that used by bricklayers. *Running rules* are strips of wood about 2½ in. by ½ in., planed all round, and of various lengths, and are fixed to form guides for running moulds.

Screed rules vary in size, usually 2½ in. by 1 in., and are used as screeds when laying concrete.

The *concrete float* [11] is similar to a parallel rule, about 6 in. by 1 in., varies in length, and has two hand holes cut in it to facilitate its use.

Hand floats [14] also are in great variety. They are mostly formed in yellow pine, except panel and mastic floats. The ordinary hand float is about 10½ in. by 4½ in., and ⅞ in. thick, with a handle at the back. The *cross-grain float* [15] is similar, but a trifle longer and thicker, and cut with the grain across the float, and is formed with a dovetailed groove at the back, into which a hardwood key, carrying the handle, is inserted, which keeps the wood from warping. This is used for scouring the setting coat. A *skimming float* is similar to a hand float, but 12 in. to 14 in. long, and ½ in. thick, and is used for laying the setting stuff. *Panel floats* are usually of beech or pear wood about 6 in. by 3 in., and ½ in. thick. They are used for laying and smoothing gauged stuff in panels and for mastic. *Fining floats* are small floats from ⅛ in. to ¼ in. thick, for working mitres in cornices, panels, etc.

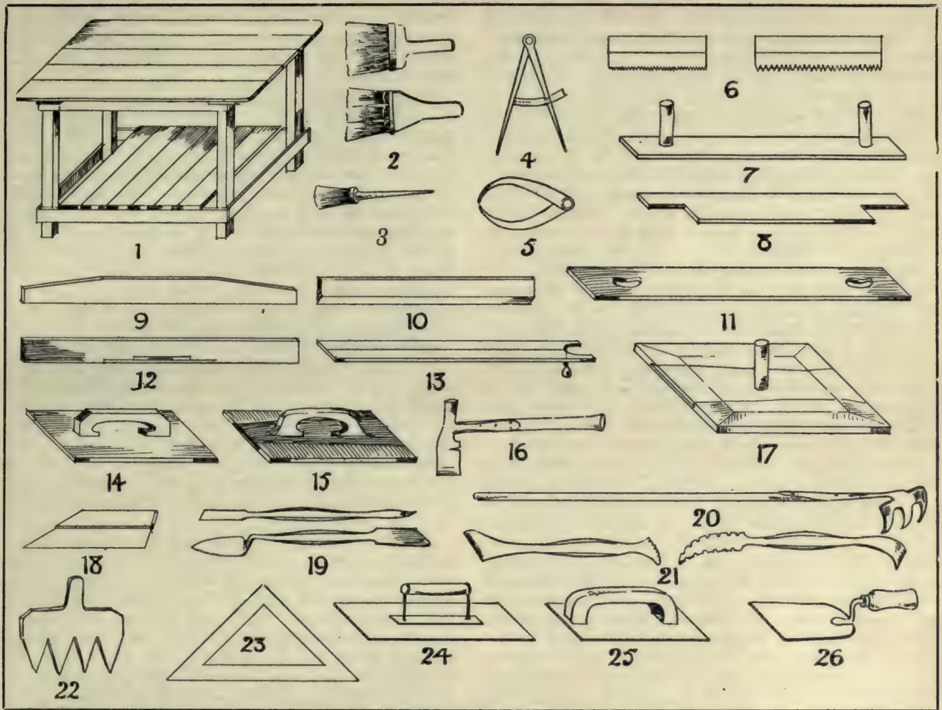
Other Tools. The *plasterer's hammer* [16] has a wood handle, with a steel head, one end formed like a hatchet, with a nick in the lower edge for extracting nails. This hammer is used for fixing lathing; the driving end is indented.

The *hawk* [17] is a piece of pine about 11 in. or 12 in. square and ⅝ in. thick. The sides are splayed at the back to about ⅜ in. thickness at the edge; a dovetailed groove is formed in the back, into which a hardwood strip, on which the handle is mounted, can be inserted. The board is cut into two halves down the centre of the groove, and hinged together for packing, and in use the strip with the handle is inserted, and keeps the two halves rigid. The board is used for holding stuff and for gauging small portions.

Joint rules [18] are usually made of a strip of steel 3 in. or 4 in. wide, and ⅛ in. thick, mounted in a hardwood stock. One end is cut to an acute angle, and this end and the edge are splayed so as to give a fine edge.

A *larry* or *drag* [20] is a three-pronged rake with a long, wooden handle, for mixing hair with coarse stuff. *Mitring tools* [19] are of various sizes and shapes, and are of wrought iron or steel; they are usually from 7 in. to 11 in. long, with a central shaft, octagonal in form and rather thick, and blades at each end. They are used for mitring and for moulding and cleaning out and stopping ornaments.

Scratch tools [21] are made in a similar manner, with a shaft and a tool at each end, and take various forms, and are used for carving, mitres of mouldings and cleaning up enrichments, and for modelling and cleaning models. *Plaster small tools* resemble mitring tools, and are usually made from brass rods, the ends beaten flat and filed to the required shape, and



PLASTERER'S TOOLS

1. Square stand 2. Plasterers' brushes 3. Tool brush 4. Compasses 5. Calipers 6. Drags 7. Darby 8. Gauge rule 9. Floating rule 10. Feather-edge rule 11. Concrete float 12. Levelling rule 13. Plumb rule 14. Hand float 15. Cross grain float 16. Plasterer's hammer 17. Hawk. 18. Joint rule 19. Mitring tools 20. Larry or drag 21. Scratch tools 22. Scratch 23. Square 24. Laying trowel 25. Panel trowel 26. Margin trowel.

the central barrel filed to octagonal form. This is sometimes bound with waxed thread. They are used in shop work for cleaning up plaster-work.

Planes similar to a carpenter's plane are used for levelling and smoothing plaster surfaces. The blades are toothed.

The *scratch* [22] may be cut out of a ½-in. pine board, and is about 14 in. long and 7 in. broad. One end is shaped, the other cut into teeth about 3 in. long, and the points 1¼ in. apart. An effective scratch may be formed with four laths fixed side by side, and pointed, and is used for scoring floated surfaces to provide a key for the next coat.

Sieves, or *riddles*, of various sizes and degrees of fineness, are made and are used for running lime and washing sand.

Squares, of wood or iron [23], are triangles having one angle a right angle, the other two angles generally being 45°.

Trowels, Etc. *Trowels* are also required of various shapes and sizes for different classes of work. The *laying trowel* [**24**] is a rectangular sheet of flexible steel, about 10½ in. by 5 in., with a handle riveted to it, sometimes with a single, sometimes with a double shank. The *panel trowel* is similar, but the blade is very springy, and about 5 in. by 3 in. It is used for setting small panels. The *gauging trowel* is made in various sizes, and resembles a bricklayer's trowel in form. It is used for gauging small portions of stuff on the hawk, and for laying stuff on mouldings, niches, stopping small holes in the plaster, and similar work. The *laying gauging trowel* is similar in shape, but larger, from 7 in. to 9 in. long, and tapering from about 3½ in. to 1½ in.; it is used for laying gauged stuff. The *margin trowel* [**26**] is somewhat similar, but the two sides are parallel, and the end square; the blade is about 3½ in. by 2½ in. It is used for laying and polishing margins, styles, and similar work. The *polishing trowel* is usually a partially worn laying trowel, but the edges should be true and parallel.

Tubs to contain water for washing sand and running lime are required, and may be formed by cutting an old spirit cask in half.

In addition to these tools, most of which are special tools, the following are also used by the plasterer:

Files and *rasps*, of different sizes.

Gauges and *chisels* similar to those used for carving wood are required for carving and cleaning-up plaster, cement, etc.

A *hod* somewhat similar to a bricklayer's hod.

Knives of various sorts for trimming enrichments and angles, and for cutting canvas.

Spirit level.

Iron and wood pails.

Saws for cutting running rules and fibrous plaster.

Screen, as used by bricklayers for screening lime and sand.

Materials. *Plaster-of-Paris* is manufactured from gypsum, which is a sulphate of lime, and frequently contains a considerable percentage of carbonate of calcium. The gypsum is got by blasting, and if dirty, the outer portions are cleaned, and may then be treated by one of two processes.

The first is termed *boiling*. For this, the gypsum is first pulverised, then finely ground, and then conveyed to a large open pan or boiler heated by means of flues, and is kept agitated by rakes revolving on a spindle. After about half an hour, a series of small explosions occur, and the process is completed in about three hours, when the gypsum becomes more dense and sand-like. It must then be turned out of the boiler, cooled, and packed. If left too long, it becomes burned, and will set only after a long time, if at all. Plaster thus made is fine, works freely, and is not liable to warp.

The process of *baking* is carried on in a flat kiln or oven, the fuel not being allowed to come into contact with the gypsum. The kiln is heated to redness, charged with the gypsum in lumps, and the heat gradually increased and continued until the whole of the water present is evaporated, generally for about 16 hours. The material is afterwards ground.

Plaster that has been calcined in lumps sets more rapidly than that ground first into powder. Good plaster, if squeezed in the hand before use, should cohere slightly and retain its form when the hand is gently opened; if it all falls to pieces it is a sign that the plaster is injured by damp. Plaster is slightly soluble in water, and cement which contains plaster to a considerable extent must not be exposed in a raw state to the weather. Good plaster should not set with great rapidity, or its manipulation is difficult. The compressive resistance of good plaster gauged with plain water should be about 120 lb. to the square inch., or nearly 8 tons to the superficial foot, and its strength is increased about 25 to 30 per cent. if gauged with lime water.

Limes. The properties and method of preparing limes and cements have been already fully dealt with. [See pages 648 and 1455.]

The method of slaking lime for use in plasterers' work differs from that used for bricklayers' mortar. The lime is completely immersed in water, about 1½ gallons of water being used to the bushel of lime, and the mass is left till completely slaked and then lifted out in pails, passed through a sieve, and run into a pit with sides of brick or boarding. The material must be left for at least three weeks, and a considerably longer period is advantageous. Lime so prepared is used for making *coarse stuff*.

Lime putty is formed in a similar way, but is run through a finer sieve into a pit lined with coarse stuff, and should be left for at least three months, and may be kept for a long time without injury if protected from the air.

Sand for lime plaster should be hard, sharp, gritty, and free from all organic matter. It should not be too fine for coarse stuff and floating coats, and should not be too uniform, containing both coarse and fine particles. Silver sand is used with Portland cement where a light colour and even texture are essential. Sand for plastering is often specified to be washed, and this should always be done, if any impurities are present, to secure good work.

Hair is used as a binding medium, giving tenacity to the material with which it is mixed. It is usually the hair from the back of oxen, and should be long, strong, and free from impurities. It is obtained in a dry state in bags and must be well beaten up with a couple of laths or light sticks to separate the hairs which are found in lumps. Goats' hair is sometimes used, and hair obtained direct from the tanneries makes the best work. Hair must not be mixed with hot lime, which weakens it, and should only be added to stuff just before using.

Substitute for Hair. Manilla fibre cut into lengths of 1½ in. to 2 in. has been tried with satisfactory results as a substitute for hair, also sisal hemp and jute, which are not quite so strong. Sawdust has been used as a substitute for hair, especially as additional aggregate for coarse stuff, and must be used dry and passed through a sieve to eliminate large pieces; it stands the effect of rough weather and frost when used externally. Some kinds of sawdust are apt to stain the stuff, and these must be soaked before use.

Laths are thin strips of wood split or rent from straight grained wood, generally from Baltic or American timber, and are made by hand, the advantage of such laths being that the fibres run continuously, whereas in sawn laths, though the latter are more regular in form, the fibres may be cut across and thus are less strong. Laths are usually made in lengths from 2 ft. 6 in. to 4 ft., but sometimes longer. They are about 1 in. wide in the face; single laths are ⅛ in. to $\frac{3}{16}$ in. thick; lath and a half, $\frac{3}{16}$ in. to ¼ in. thick; double laths, ¼ in. to ⅜ in. thick.

Laths are fixed usually from ¼ in. to ⅜ in. apart, depending on the nature of the plaster. In good work the ends are butted where joints occur over a joist or quarter, and the line of joints should be frequently broken. They are secured with clout-headed nails from ¾ in. to 1¼ in. long and should be nailed at every bearing; the nails may be wrought, cut, or cast, and are best galvanised, to prevent rusting. When secured to timbers more than 3 in. broad on the face, the latter should have double laths or fillets nailed along the face to avoid interfering with the key of the plaster, which is formed between each pair of laths; this is termed *brandering* or counter lathing. For lathing of half timber work laths rent from oak are sometimes used. Lath and a half should be used for ceiling and soffits, and is generally used also for partitions, except in rather inferior work.

Substitute for Laths. Sheets of metal variously prepared are now frequently used in place of wood laths, and have the advantage of being non-combustible. The most usual kinds are *expanded metal* lathing, which forms a kind of inset and gives a good key to the plaster; it can be obtained in large sheets and can be adapted to irregular surfaces.

Thilmil consists of thin steel sheets from 5 ft. to 6 ft. long and from 12 in. to 24 in. wide, perforated with sections alternately raised and depressed to afford a key; this may be fixed to small iron standards in forming fireproof work.

Dovetailed metal lathing has already been described [page 4756], and is an excellent substitute for wood laths.

Plasterer's Terms. Plastering is applied both to solid surfaces, such as brick, stone, or concrete, and also to surfaces formed by laths laid side by side. In almost all cases there are at least two coats laid on and very often three. On solid walls one-coat work is usually described as *rendering*; two-coat work as *render and set* or *lay and set*; three-coat work as *render, float and set* or *lay, float and set*. On partitions the work is described, if one coat only, as *lath and plaster* or *lath and lay*; if two coats, as *lath, plaster and set* or *lath, lay and set*; three-coat work, as *lath, plaster, float and set* or *lath, lay, float and set*.

The term *plaster*, if used alone, is generally taken to indicate work executed in plaster of Paris. The material in general use, composed of lime, sand, hair, and water, is generally termed *lime plaster*; but there is a good deal of uncertainty and laxity in the use of plasterers' terms, which vary in different districts.

Coarse stuff, or *lime and hair*, or hair mortar, consists of $1\frac{1}{2}$ parts of sand to 1 of lime putty mixed with water, and to this is added beaten hair in the proportion of 1 lb. of hair to 3 cubic ft. of stuff, and this is thoroughly incorporated with the larry. When well mixed in sufficient quantities the hairs should be found about $\frac{1}{16}$ in. apart; and if a little is picked up with the end of the trowel, it should cling to it and not drop off. The consistency is important, as, while it must be plastic enough to work, if too soft it will drop off, especially in the case of ceilings.

Fine stuff or *setting stuff* consists of fine lime putty and fine, sharp, washed sand. The proportions vary somewhat, but the general proportion is 3 of sand to 1 of putty. It may be allowed to stand after thoroughly mixing till nearly hard but not dry, and is then knocked up again to the required consistency with water or lime water and at once used. It is less likely to shrink and crack if used in this manner. It may be mixed with colouring matter to any desired tint, or with materials that will give it a brilliant or marble-like surface; this is done by omitting one part of the sand and substituting for it one part of crushed marble, alabaster, or spar. Some white hair was often mixed in the setting stuff where only hydraulic lime was available, which cannot be easily manipulated, but is not so often employed now.

Gauged stuff is a term applied to either coarse or fine stuff which has a certain proportion of plaster of Paris mixed with it. This is done with the object of shortening the time within which the material will set. For coarse stuff and setting stuff one part of plaster to four parts of stuff may be used, or a larger proportion of plaster up to an amount equal to the coarse stuff, depending upon the rapidity of setting required and the strength of the plaster. For heavy cornices the proportion should not be lower than 1 to 3, which is also the proportion used with putty.

Stucco. *Stucco* is a term somewhat loosely applied to various plastic mixtures in England, and has been to some extent superseded by Portland cement for external work, and by Parian and other similar cement for internal work. It differs from ordinary three-coat work mainly in the manner of mixing and working the final coat, the first two coats being similar to three-coat work.

Common stucco is composed of 3 parts coarse, sharp sand and 1 part of hydraulic or grey lime and a little hair, and is used for external work, and the surface is finished with a hand float.

Rough stucco is used largely for interiors and in imitation of stone. It is formed with three parts of coarse sand and two parts of greystone lime. It is laid with a trowel, and after being ruled in with a straightedge, is scoured with a hand float, and afterwards with a felt float, which is an ordinary float the surface of which is unplaned and covered by a felt pad. The surface of the stucco is patted with this, and may be made to resemble the texture of stone, and, if required to represent ashlar, joint lines may be indented in the required positions with a jointer. This work may be tinted to represent the colour of stone by mixing with it ochre or other colour with dilute sulphuric acid.

Trowelled stucco is used for work that is to be painted; the coat is formed with $2\frac{1}{2}$ parts to 3 parts of sharp washed sand, not too fine, and 2 parts of chalk-lime putty, and is laid and traversed in all directions with a floating rule, then scoured without water, and after an interval scoured again with water and immediately after with the trowel, which is continued till the work is so hard that no impression is made, and finally brushed over with a soft damp brush. The surface when dry is excellent for paint.

Plaster Work. The method of carrying out ordinary three-coat work is as follows: the first coat is formed of coarse stuff, and applying it to walls, partitions, or ceilings is described as *pricking-up*. The material is placed on the hawk, and thence transferred with a trowel to its position; in the case of ceilings, it is first worked on in a diagonal direction as the laths are stiffer when this is done, and each trowelful is partly covered by the succeeding one. It must be laid with sufficient pressure to force it between the laths to create the necessary key. The coat is laid as evenly as possible, from $\frac{3}{8}$ to $\frac{5}{8}$ in. thick.

The first coat on walls is termed *rendering*, and is similar in substance; the walls are well swept over with a coarse broom, and thoroughly wetted, to prevent the brickwork from absorbing the moisture from the rendering. The joints should be raked out for a depth of about $\frac{3}{4}$ in. before the mortar is set, to give a good key.

The first coat, after laying on both walls and partitions, must be *scratched* or *keyed*. The work is allowed to stand for an hour or two till it is firm; the scratch is then applied uniformly over the surface diagonally and crossed; scratching may be best done with a single lath, but takes much longer than with the scratch; the object of scratching is to provide an efficient key for the next coat.

Floating. Applying the second coat is termed *floating*. This may be done at any time after the first coat is dry, but if it has been left some time, it should be swept over to get rid of dust, and a damp brush should be passed over it. The material used in this coat is also coarse stuff, but it requires to be more plastic, and may have rather less hair than first-coat stuff. This coat brings the surface of the wall to a fairly true face, and must be carefully prepared for. The first process is to form screeds, which are thin strips of plaster, to serve as guides to the floating rule or running mould. In plumbing, an ordinary plumb rule may be used, or a line and plummet. The first process is to form *dots* top and bottom, unless the skirting grounds are available for use in place of bottom dots. The upper dots are formed just below the cornice level; they may be formed by nails driven through the first coat, and the head left projecting about $\frac{1}{2}$ in., and they are adjusted with the plummet till perfectly in line, and their projection gives the proper thickness for the floating coat. The dots are finished by laying narrow strips of gauged stuff in a vertical line with the nails; these are worked down with the floating rule till they correspond in thickness with the projection of the nail. These dots may also be formed with pieces of lath about 6 in. long on a piece of coarse stuff, the thickness being adjusted with the plummet. When the top and bottom dots are completed, and are truly in a plane not only vertically but horizontally, vertical screeds are laid between each pair of dots and worked perfectly true with the rule. These vertical screeds should not be more than 6 ft. to 9 ft. apart, and when completed the nails used for dots are extracted.

Flanking. When the screeds are hard, if the surface of the first coat is seriously hollow in places it should have additional material laid on and scored; then each bay is laid with coarse stuff, which is worked upwards from the bottom, and the surface is then ruled even between the screeds with a floating rule, which carries off any superfluous material. Any hollow places must be filled up. This process is termed *flanking*, and is continued till the whole wall surface is covered and forms a perfectly true plane surface. Even if, as in common work, the screeds generally are not truly plummed, any salient angles must be so dealt with. Dots are similarly prepared for ceilings, and are made perfectly level with the help of the levelling rule, and screeds are then formed and the flanking completed. At angles the float cannot work close, and a seam is left; this is trimmed off square with the laying trowel after all floating is complete.

Scouring. *Scouring* the floated coarse stuff hardens the surface and prevents cracks in it and in the setting coat. The floated material is allowed to stand till the moisture has evaporated from the surface and it is firm. Scouring is carried out by a hand float, which is pressed hard upon the material and passed rapidly over it with a circular motion. The float is held in one hand, a stock brush in the other, and with it the surface is sprinkled; any small hollows left by the float may be filled in, and the whole surface should be treated in a uniform manner. A second scouring, and in very good work a third, may take place after an interval of from three hours to five hours, and the last scouring is continued till there is no moisture on the surface. Scouring is not required for Portland cement or when this coarse stuff is mixed with hydraulic lime.

Keying. The effect of scouring is to leave the floated surface smooth and close, and if the thin setting coat is laid on this, adhesion between the two is apt to be imperfect; after scouring, therefore, the surface must be made rough to secure the necessary key. This is done by brushing the surface as soon as scoured with a stiff whalebone broom, or by the use of a *nail float* which is an ordinary float having the point of a nail projecting from it about ⅛ in., or with a *devil*, which is similar, but has four such points, one near each angle. This tool should be worked with a close circular motion, and scores the surface, thus providing a key for the setting coat. Cornices are run before the final or setting coat is laid, but the work on this coat will be considered as following on, and cornices dealt with later.

Setting Coat. The material used for the setting coat is *fine stuff* or *setting stuff*, and has been already described. It should not be applied till the floating is well set and nearly dry; but if it has become quite dry it should be well wetted a day or two before the setting coat is applied. The setting is laid in two coats, one directly after the other, and both coats are laid with a skimming float. As soon as one wall, or bay, is completed, it is scoured, trowelled, and brushed.

Scouring is carried out with a hand float, and water is applied with a stock brush. After a short interval the operation is repeated, and it is finally scoured with a cross-grain hand float, with a sparing use of water, and is continued till an even close-grained surface is secured. This work is followed up by trowelling, for which the work is again sprinkled and the trowel well worked over the surface, which is afterwards brushed over with a wet stock brush, and finally with a half dry one. The thickness of the setting coat is usually about ⅛ in., and if the wall is required for painting, screeds may be used for the setting coat.

In the case of second-class work, the setting coat is laid as a single coat, scoured and trowelled once and brushed over, and in inferior work the coat is very thin, formed of quick-setting stuff, and is then trowelled and brushed.

Internal angles must be carefully squared and made true with a cross-grained float. External angles may be treated in various ways, beaded or moulded or finished with an arris. Sometimes a wood bead or wood bullnose is used to form the angle. The circular bead is fixed to the walls, and the floating coat is cut away on each side to form the guide when the setting coat is laid. Unless the angles are in wood, they are usually in Parian or Keen's cement, and this material is returned on each face for about 2 in. The floating is cut away to a square line down to the brick, which is dusted and wetted, and the bead or arris is then run, running rules having been fixed on each side; the edge of the return forms a finish for the setting coat.

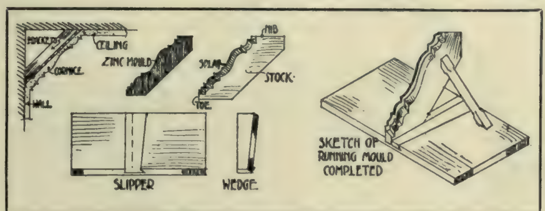
Working Keen's, Parian, and Martin's Cement. These cements are largely used for plasterer's work in place of ordinary lime plaster. Much economy of time may be effected by their use, and they may also be painted, papered, or distempered as soon as finished. They work easily, and give a very smooth, hard surface, and when not used generally for plastering, are very usually employed for salient angles and similar purposes. They will not, however, resist the effect of moisture, and are not therefore suited for external work; if used in internal walls that are in any way damp, such walls must first be rendered in Portland cement. Care must be taken to see that they are used without addition of plaster, which may cause them to swell. The cost of these cements is higher than that of plaster. In the case of lathwork, the nails used must be galvanised, or otherwise protected from rusting, and all nails used in forming dots must be extracted. For first coat and floating on ceilings the proportion used are 1 of cement, 2 of clean, sharp sand, and hair in about the proportion used for lime plaster; for walls a little more sand may be used—about 2 of cement to 5 of sand. A coarser form of cement is used for the earlier coats than for the final coat. Where it is not desired to proceed rapidly with decorating, the walls may be rendered and floated with Portland cement and sand, used in the proportion of 1 to 3; this is more economical, but generally results in a white efflorescence appearing on the surface, and must be given time to dry out before the surface can be painted or otherwise treated.

The materials must be carefully mixed dry and then the water added and finally the hair, which should be first beaten and soaked. The material is used fairly stiff, and it is important that any work begun should be finished on the same day. The first coat when finished is scratched, and should stand for about 20 hours before floating. The screeds for the floating coat are generally narrow, and the sides are cut square, and the material, when these are set, is ruled in with a floating rule till the surface is perfectly even and true, and when firm it is brushed over with a coarse broom to provide a key.

For the finishing coat a fine cement is used and generally worked neat. It is first gauged smooth and stiff and may have additional water added afterwards to reduce its consistency if necessary; this coat should not exceed ⅛ in. in thickness and must

be carefully ruled till perfectly true. It is laid generally in two coats, the first fairly stiff, and after this has been ruled, additional cement gauged less stiffly is laid and ruled. In about an hour or so it becomes firm, and may then be scoured without much water, the operation being twice repeated to secure a firm, close, even surface. Trowelling follows on soon after scouring, very little water being used, and this operation is also twice repeated.

Preparing for Cornices. Cornices must be provided with some kind of core to which the plaster can be applied. In the case of external cornices this may be of rough stone or brick built into or corbelled out from the wall, which should conform closely in its outline to the finished lines of the cornice. For internal cornices the preparation will depend on the size of the cornice and its form. When the projection is small, a series of spikes may be driven into the wall, the heads being left projecting to the extent required to form the mouldings and tarred bands twisted between them; but where the section of the cornice has a considerable projection, brackets are used cut from boards and fixed at intervals in the angle between ceiling and wall. These are afterwards lathed with ordinary laths or with metal lathing. These brackets should be cut to such a shape as to secure that the thickness of the plaster should be approximately equal throughout. This cannot be secured at every point, but should be aimed at; if thinner, the plaster may crack; if thicker, it is wasteful, and unduly loads the brackets. Any small mouldings projecting considerably from the general line may be strengthened by the use of projecting nails. The actual section of the bracket must be varied for a plain and enriched cornice, even if of the same profile, as the enrichments cannot be run, but must be cast and a bed formed for their insertion.



27. RUNNING MOULD

Cornices. Cornices are formed by means of a running mould [27] cut to the profile of the proposed mouldings. The actual mould for forming the profile is now usually of zinc, except in the case of Portland cement mouldings, when iron is often used. The thickness of the zinc may be about $\frac{1}{16}$ in. or a little less, and the zinc profile, or *plate*, is fixed on a wood backing, or *stock*, which in turn is fixed to a wood plate, or *slipper*, and supported by stays which form handles. The plate is marked with the desired profile, cut, and then filed perfectly true, and is usually about 4 in. or 5 in. in width, and has squared ends of about $1\frac{1}{2}$ in. corresponding with wall and ceiling surfaces. All woodwork is carefully planed; the stock is cut to a profile corresponding with the plate but set back about $\frac{1}{16}$ in. except at the *nib*, or upper edge, which bears on the ceiling, and the *toe*, which bears against the wall and assists the plate to run freely. The edge of the stock is splayed back from the plate still further; the stock is made wider than the plate, which is screwed or nailed to it; the bottom of the stock is fitted into the slipper, which is carefully squared and grooved with a dovetailed groove, into which the stock is fixed by a wedge and secured with nails. The handle or stay is formed out of a square piece of wood the angles rounded off in the centre; the ends are splayed and fixed, one to the stock and one to the slipper, so as easily to clear the moulding when grasped by the plasterer's hand in working. When the mould is to have considerable use, the nib and each end of the slipper may be protected by a piece of zinc or leather. A splashboard is sometimes added, and is fixed between the back edge of the slipper and the stock.

In preparing a running mould for an enriched cornice the enriched members are omitted and a bed sunk for them which can be run with the other mouldings and into which the cast enrichment is afterwards inserted.

Running screeds are prepared on the walls as bearings for the mould, and the running rules are then fixed. These are long strips of wood $2\frac{1}{2}$ in. to $3\frac{1}{2}$ in. broad, and $\frac{1}{2}$ in. thick, planed all round, and fixed against the screeds, and form guides for the running moulds.

The mouldings are first roughed out, and then finished with a fine thin coat, and for this roughing the running mould which gives the finished profile must be *muffled*—that is, the edge of the mould must be covered to an extent equal to the thickness of the final coat. This may be done by gauging up plaster and covering the bevelled edge of the stock with it till the plaster projects about $\frac{1}{4}$ in. beyond the plate, and, when it has set, trimming it down to about $\frac{3}{16}$ in. projection, which will leave sufficient thickness for the finishing coat. Another method is to provide an extra *muffling plate*, cut to the requisite profile, and screwed over the plate. When the moulding has been roughed out, the muffling is removed, and the plate used for finishing.

Running Cornices. Where brackets and lathing are used, the laths are often coated with gauged coarse stuff and scratched before the screeds for floating the walls are prepared. This dries and stiffens the lathing before the mouldings are roughed out. With large mouldings, and when metal lathing is used, the whole cornice is roughed out with gauged coarse stuff. This must be laid on in regular thickness, the form of the mouldings being built up as nearly as possible with the trowel first, and the muffled mould is then run over the mouldings, carrying off any superfluous material; any hollow parts must be filled in, and the whole cornice brought to a true and uniform profile throughout ts length.

Finishing Cornices. The gauged stuff for finishing must be prepared on a clean gauge board. The plaster and water are first mixed, and the putty afterwards added; the stuff is laid in the cornice with a gauging trowel, following the form of the mouldings; the mould is run along by one man, except in the case of very large mouldings, when two may be necessary. Any members of the cornice not properly filled out must be fed with additional stuff, and the operation goes on till the cornice is complete. Finally, a thin coat of fine putty, gauged with less plaster, is drawn over the mouldings, and the mould is quickly and steadily drawn along the whole cornice as a finish.

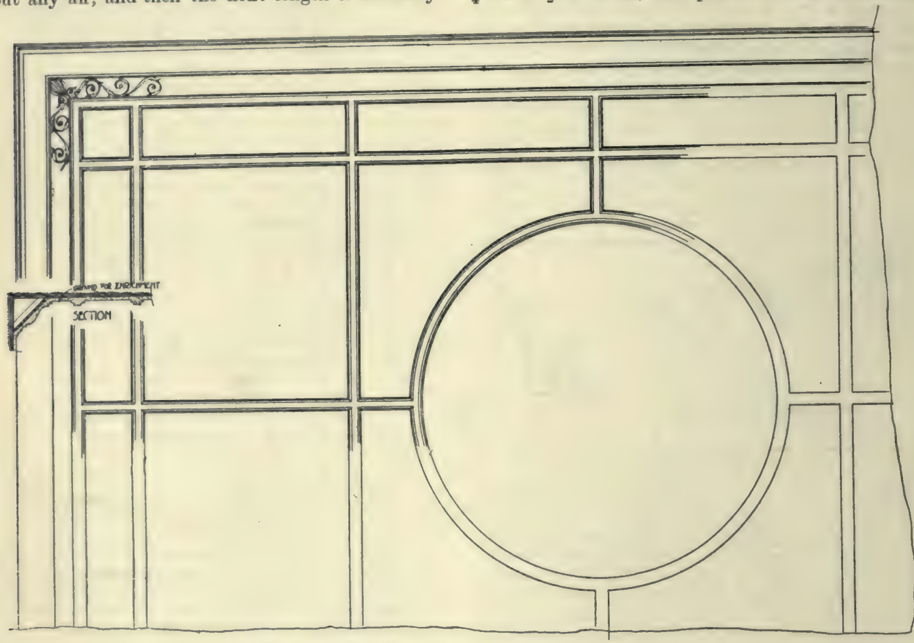
Mitring. Where two walls meet at either an internal or external angle the cornice on these walls meets in a mitre line. This section cannot be run with an ordinary mould, and though mitre moulds are sometimes employed, these angles are, as a rule, made by hand, and are mainly worked with the joint rule, the smaller members and those at the top and bottom being first worked, and the larger

members ruled in afterwards. *Small tools* are used for laying in the stuff, cleaning out the intersections, and stopping any small holes.

Fixing Enrichments. In the case of a cornice which is enriched—that is, in which the mouldings are cut on the face, and are not therefore uniform in section, the enriched members cannot be run, but a sunk bed is formed for them, and the enrichments are cast in blocks and set in the finished cornice. The beds are scratched when formed, and, for fixing, the bed is dusted and wetted. The fixing stuff, which is fine gauged stuff, is spread thinly over the bed to fill up the scratches, and over the back and sides of the cast; and the heading joints are covered with a little fine plaster gauged with size water. The cast is then inserted in position, slid backwards and forwards to drive out any air, and then the next length is similarly

Rough Cast. *Rough cast* is a method of finishing external walls, and may be used for plain surfaces or in conjunction with timber framing; it is also known as *pebble dash.* It is a very durable form of plastering, and produces a surface of a rough texture, much superior in effect to a smooth plaster face. When executed in lathing, the laths used should be double laths. The first coat is formed with coarse stuff having a liberal amount of hair, which is scratched; or the first coat may be formed of Portland cement in exposed positions. The second coat is also of coarse stuff, well worked to an even consistency, and not applied till the first coat is thoroughly dry; this coat is laid fair, and while still soft the final coat is applied.

The final coat is usually formed of shingle or fine gravel, well washed and passed through a sieve from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. mesh, and put into a tub containing



28. PART OF PANELLED PLASTER CEILING

treated. Great care is required in setting out any enriched members so that they shall repeat an exact number of times in a given length, and any necessary adjustment must be made so as to secure a proper mitre. This is arranged for as far as possible in the shop.

Such casts are usually made in moulds of gelatine; specially prepared wax and plaster are also employed for making moulds for casting plaster ornaments and enrichments, but the details of their preparation cannot be entered upon in this article, which deals with the work more directly connected with actual building operations. Moulded work is not confined to cornices, but may be used in many other situations, especially in ceilings [28] and in forming panels and other enrichments for walls. In the case of elaborate moulded ceilings, especially where the mouldings are small and not run in straight but in curved lines, these may be cast in moulds and applied as described for cornice enrichments.

hot hydraulic lime, mixed with water into a fluid state and well stirred. The shingle is taken out as required, and thrown or dashed evenly on to the soft second coat with a scoop, or hollow trowel, and forms a rough but regular surface. Ochre or other colour may be mixed with the lime to give a tint to the rough cast surface.

Repairing Plaster Work. Where cracks in ceilings are only slight they are often merely stopped before the ceiling is rewhitened, but large cracks and loose plaster must be carefully cut out; care must be taken not to disturb adjacent work, and in forming patches sharp angles are to be avoided. The edges of the old work must be cut neat and square, and in some cases the lathing may have to be made good before replastering. The edges of the old work must be wetted, and the laths just damped after dusting. The repair is generally executed in gauged coarse stuff and gauged fine stuff, or in best work with Parian or Keene's cement.

PLASTERING *concluded; followed by* INTERNAL PLUMBING

MAKING MILLINERY BOWS

The Art of Making Effective Bows and Rosettes of all Kinds. The Butterfly and Alsatian Bow. Chiffon and Tulle Rosettes

continued from page 5332

By ANTOINETTE MEELBOOM

MILLINERY bows are made in a great number of shapes and sizes. They may be made of silk ribbon of an immense variety of kinds and widths, velvet ribbon, lace, piece velvet, chiffon, tulle, straw, kid, braid, beaver, cloth, etc., but each bow is made on the same general principle. Before using new ribbon, it is better for an inexperienced worker to practise on a piece of muslin, or even tissue paper, cut in strips the width and length of the ribbon; for when once the ribbon is creased, it cannot very well be altered without taking away the freshness of its appearance. By practising in this way, the beginner will obtain that lightness of touch, quickness, and "finger-knack" which is so necessary in all millinery trimmings, and especially in bow-making. She will, in a short time, produce bows which would be a credit to an experienced milliner.

Bows are always made by hand before they are sewn on, except in the case of large hats with a bow or rosette at each side and a piece of ribbon going across the centre.

When making the bow, the hat for which the ribbon is needed should be in front of the worker, to get the size and effect. Bows are best made from one length of ribbon which is not more cut than necessary, unless a bow with many ends is required.

A bow, although it should appear to be untouched by hand, must yet be firm. When buying ribbons for bows take care that the assistant does not crease up the ribbon to show how it will look, as the crease may happen to come across the widest part of the loop. The following characteristics of a well-made bow should be noted:

Pleats should be even, fine, and straight;

Each loop and end brought back to its root or starting point, and the bow made in one piece, if possible;

The ribbon kept fresh-looking, free from twists and any re-arrangements;

The size of loops made in accordance with the width of the ribbon;

The wire (if used) firmly fixed, and the ribbon sewn lightly to it, free from strain.

We shall first make a few bows which never go out of fashion. To keep up-to-date in the latest shapes of bows it is necessary to study the fashions prevalent at the time. Those who have an opportunity of visiting trade houses will have a great advantage. Otherwise, careful observation of the best milliners' windows, of well-dressed people in the parks and promenades, of ladies' magazine advertisements, will help the milliner to see what is most in vogue. Even if she has no originality, she will at least be able to copy, after practising the instructions we shall give.

The quantity of material required for a simple bow is ¾ yd. of 5-in. wide ribbon. Start at one end—not in the middle. Hold the ribbon in the right hand, and with the left pleat it firmly and evenly.

Bind it *tightly* round the pleats with mounting wire, inserting one end of the wire in the pleat; or with cotton, using a strong needle and No. 10 cotton. Insert the needle once through the pleats and turn the cotton round tightly three times; put the needle through again [**128**].

Gauge the length of the loop by the width of the ribbon—the wider the ribbon the longer the loops. Pleat the ribbon *evenly*, and bring the pleated part back to the centre, and bind it tightly with mounting wire or cotton, having the loop *opposite* the end just made [**129**]. This centre is called the *root* or *waist* of the bow.

If there is a right and wrong side to the ribbon, as there is in velvet ribbon with satin back and most ribbons with patterns on them, give it a sharp twist to keep the right side up, before making the second loop. To pull up the loop, place the forefinger inside. Never crease or touch bows more than is just necessary to secure them.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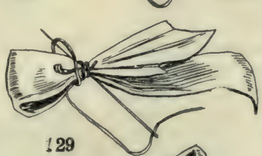
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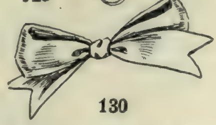
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128–130. A SIMPLE BOW

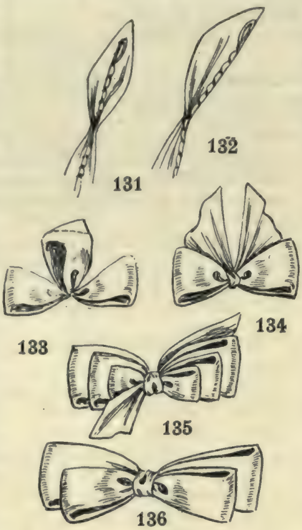
Make another loop in the opposite direction, which will place it on the top of the first end, and for this simple bow make it the same length as the first loop, bringing it back to the root or starting point. Cut off the ends slantways, or fray them out. The triangular piece cut from the first end will make the tie-over. Turn in cut edges, twist it over the root, and neatly finish off at the back with a few stitches [**130**].

On this principle all other bows are made. They may be varied by having several loops of different lengths, but they are always placed alternately right and left to the root.

Good ribbons require no stiffening, provided the loops are not too long. Large bows of wide ribbon, and all soft ribbons, require wiring. Use support wire or ribbon wire, shredded. Of the last, use each strand of the wire separately, which can easily be done by tearing it along the soft part. Wire-stitch it along the centre, and zig-zag it for wider soft ribbons. Use very fine sewing silk to match the ribbon, and let the stitch taken

through be hardly visible [131 and 132]. In the same way, coloured support wire to match the ribbon can be used. It is a little more difficult to manipulate, but a lighter effect is obtained.

Ribbon wire can also be used. Place the end of the ribbon wire inside the centre pleat, bring the needle through, bind it round with cotton, and take the needle through again. Gauge the length for the loop, and allow the same length for the ribbon wire; bind it over with the ribbon, and stitch it and bind round the root of the bow. Be careful not to strain the ribbon tightly on the wire.



THREE STYLES OF BOWS
131 and 132. Wiring the bow
133 and 134. Butterfly bow
135. A tied bow 136. Alsatian bow

Secure the wire at the back with silk to match the ribbon, just below the top of the loop.

Upstanding or broad ends should be wired half way up, never quite to the top. In some cases the ends are wired along one or both sides of the ribbon.

A butterfly bow [133 and 134] can be made in rather narrow width ribbon, in which case it will be used for bonnet trimming. It has two loops and two upstanding ends, shaped at the end as butterfly wings. It also makes a handsome trimming for front of hat if made of a ribbon 9 in. to 10 in. wide, or a piece of silk.

Start this time with a loop, pleating each side separately. Make another loop in the opposite direction; then another standing up in the centre, turning in the end inside, passing the cotton used to secure the bow at the root through and through the loop. Place the tie through the centre loop. Cut this slantways [134], and shape the ends like butterfly wings. Quantity of ribbon required is ⅝ yd. of 2-in. wide ribbon velvet.

A tied bow [135] has as many loops of various sizes as desired, but only two ends, and is made, including the tie-over, in one piece. It is useful for children's washing hats and bonnets, and for various other millinery items. Keep the first and second loop the longest, graduating the length of each pair of loops. Begin with an end, next a loop 12 in. long, in opposite direction; another loop the same length, opposite the first, 12 in. long; then two loops 9 in. long, and two loops 6 in. long. Take the remainder of the ribbon, twist it round the root, and pull the end through the twist at the back, and the bow is finished. This bow can be made without the use of any cotton or mounting wire; the loops are kept firmly in place with the fingers till the tie-over—that is, the second end—secures them. Quantity of ribbon required is 1¾ yd. 5 in. wide.

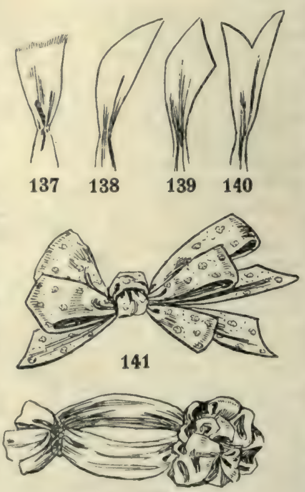
The Alsatian bow [136] takes 1¼ yd. of 3-in. wide ribbon. It is made of four loops, has no ends, and a large broad tie-over. Loops Nos. 1 and 2 are 12 in. long; loops 3 and 4, 10 in. long. These are used frequently for nurses' bonnets, etc., the loops reaching from ear to ear from the centre of the bonnet, only once pleated in the centre.

Fancy bows [141 and 142], with more than two ends, and more than two or four loops, are made on the same principle as described, several of the loops being cut after the bow is made. If upstanding ends are required, the tie-over is taken round them, and for a flatter trimming the tie-over is taken in the centre in the usual way. Two and a half yards is the very least quantity which can be used to trim a hat satisfactorily; if it is to be its sole trimming, 3½ yd. is an average quantity. For ruches, loops, and rosettes, more is required.

Ends of bows may be frayed [137], cut in wing [138], mitred [139], or cut to fishtail shapes [140]. The ends are sometimes vandyked, or treated in some other fashionable way.

Kilting the ribbon [143] makes pretty, effective bows or rosettes. Plain ribbons look better kilted than brocade, chené, or fancy ribbons. Mixing ribbons of different tones of the same colour makes smart bows. In the good French ribbons at least three shades of the same colour can be obtained, toning gradually from light to darker.

Piece velvet bows [145] are made of velvet cut on the cross and the edges roll-hemmed. The loops are pleated as in ribbon bows; but as velvet is so much thicker, it should be twisted as little as possible, and if a large bow is required, it must be made in two parts. About ¾ yd. on the cross is required, and the tie-over should be neatly made.



A FANCY BOW AND ENDS
137-140. Bow ends
141 and 142. Fancy bows

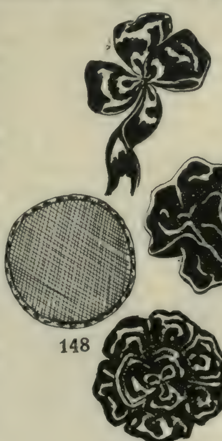
Bows of straw, braid, etc., are made in the same way. Lace insertion sewn between the rows of straw, or gauged tulle, chiffon, or silk all make pretty variations of bows. Two or even three colours of straw worked in one bow or rosette are also very effective [144].

In stitching bows to the hat, stitch firmly, stabbing the needle in the hat through the back part of the tie-over. Tie inside. Catch each loop to the brim with an invisible tie-stitch in a becoming position.

Rosettes. Rosettes are made in ribbon, lace, tulle, silk, velvet, or straw. Like bows they are continually changing in style, and even a greater variety and greater originality is displayed in the last new ones. The following are a few of the standard styles, which always remain in vogue.

The loop rosette [**146**] consists of a succession of loops each made independently, but all coming back to the centre or starting point; $1\frac{3}{4}$ yd. of 7 in. wide ribbon is needed. Start with a loop 7 in. long. Pleat the ribbon and twist round the cotton at one end as in diagram **128**; take the ribbon over the forefinger and pleat at 7 in. Then bring it back to its starting point and twist round the cotton, which will form the centre or root. Make five, seven, or nine loops, each being brought back to the centre and the cotton twisted round. The number of loops depends on the width of ribbon and size of rosette desired.

Arrange the loops in circular order, finishing the last one in the centre, unless an ornament, floral, or other fancy centre is going to be made [**149**]. Be careful the loops are close together, for if each loop is not stitched to the starting point a gap will be left between, taking away the rounded, full look. The name "chou" is sometimes given to this rosette when made very full and with rounded top. Most of the other kinds of rosettes require a foundation to which to sew the loops. For this cut a circle, about 3 in. in diameter, of buckram or double French net [**148**]; wire round with support wire, overlapping the ends for 2 in., and bind with sarcenet ribbon. Another way of making a rosette is with very small loops only 3 in. in entire length, sewn on a foundation, round and round. It takes $4\frac{1}{2}$ yd. of ribbon for each rosette, and has a flat appearance.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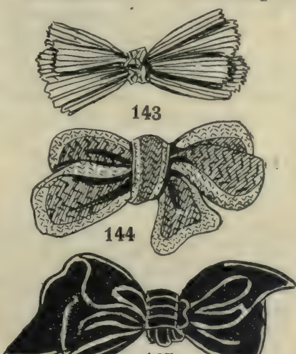
148

149

ROSETTES

146 and 149. Loop rosette
147. Crossway rosette
148. Foundation for rosette

For crossway silk or velvet rosettes [**147**] cut the velvet or silk twice the width required, and let the length be according to the width and size of rosette. The narrower the velvet the smaller the rosette, and vice versâ. One crossway length of velvet of about $\frac{3}{4}$ yd. long and $3\frac{1}{2}$ in. wide makes a small rosette suitable for a bonnet, or to fill up a small space on a bandeau at the back of the hat. This size can be made without a foundation, and two lengths are better than one. To make this, shade and join the velvet; run the raw edges together with strong cotton and pull it up tightly. Sew it to a foundation; do not skimp the outside edge, and finish it off neatly in the centre.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144

145

FANCY BOWS

143. Kilted bow 144. Straw bow
145. A piece velvet bow

Gathered ribbon rosettes are made in exactly the same way, except that the ribbon is, of course, on the straight. Gather it either along one edge or through the centre. Pull the cotton up tightly.

For silk rosettes, if not used double, roll hem-stitch, tuck, or bind one edge to form the trimming.

For crush rosettes of velvet or silk cut a circle of velvet or silk from 9 in. to 20 in. in diameter [**154**]. If the velvet or silk be soft, use a light leno or book-muslin for interlining. Gather it all round, draw up to the circumference of foundation. The centre will fall in light folds and puffs, which secure here and there to the foundation with the tie-stitch. The better the quality of the velvet, the lighter the rosette will look, and the fewer the stitches needed to keep the puffs in place [**150**].

Odd bits and cuttings of velvet or silk of any shape or size can be used for this rosette, gathered up round the edge and sewn in.

For baby ribbon rosettes [**151**] mark on a piece of net a circle the size of a shilling. Make each loop by folding the ribbon over the finger, and stitch it to a foundation on the outside of the circle marked, then another circle just inside, and so on until the foundation is covered. Finish in the centre with three upstanding loops. Quantity required is 6 yd.

There is another method of making these rosettes—without a foundation. Wind the ribbon entirely round a card $1\frac{1}{2}$ in. wide and about 7 in. in length. Let each loop just overlap the last, and do not wind tightly. With a needle and strong cotton run through the top of the loops, carefully picking up each one. Slip the ribbon from the card, removing the loops in succession, draw up tightly and fasten off securely.

Chiffon rosettes [**156**] need $1\frac{1}{2}$ yd. of double-width chiffon, cut through the centre selvedge way. This will make two or three smaller size rosettes.

Make a fold the width required; pin this down, and make another narrower fold, and pin again. Run two or three gathering threads through all the folds at the bottom, draw up tightly and stitch together; finish off the centre with an ornament. Pull out each fold to produce a full, rounded appearance.

Chiffon, net, or tulle rosettes are made with the material cut on the straight; run the two raw

edges together, draw up, and wind round from centre outwards.

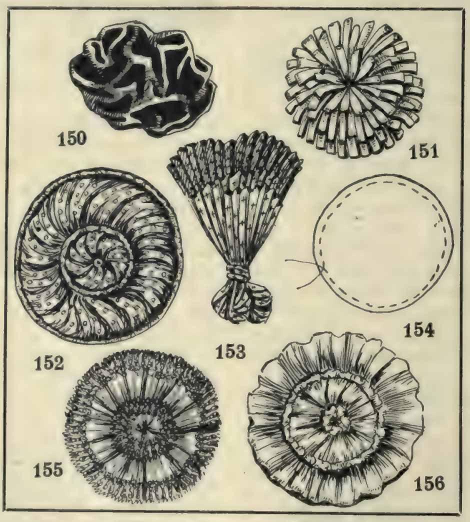
For lisse, net, or tulle, the cut edges are sometimes turned to the centre, box-pleated there, and drawn up. The wider the rosette the greater the amount of fulness required, as it will want more material to set without skimpiness round the outside edge. Avoid showing raw edges, and finish off the ends neatly.

Tulle rosettes take 2 yd. of double-width tulle and 6 yd. of lace insertion, ½ in. wide [**155**].

Cut the tulle in strips 9 in. wide, fold them in half, and sew the lace on to the fold so that it stands out well. Gather the two cut edges. The lace can be sewn on about ½ in. from the "centre edge." Tulle rosettes sometimes have their folded edges cut after they are drawn up; it gives a pretty, fluffy appearance, though they do not wear so well.

A cockade rosette [**153**] for bonnets or toques, requires 1½ yd. of 8-in. wide ribbon; if two shades are used, ¾ yd. of each is enough. Kilt the ribbon and make three ends; wire at one edge, unless a firm silk ribbon is used, and make two small loops and a tie-over.

For a drawn silk rosette [**152**] cut ¾ yd. of crossway silk in two lengths; join them in a circle. Run ½ in. tuck along the edge and another through the centre. Insert a cotton cord in each, and gather cut edges tightly to form the centre, which is finished with an ornament. Secure outer edge to foundation, also the second cord.



SOME EFFECTIVE ROSETTES

150 and **154**. Velvet rosette **151**. Baby ribbon rosette **152**. Drawn silk rosette **153**. Cockade rosette **155**. Tulle rosette **156**. Rosette of chiffon

Kid, braid, or straw rosettes are made in the same way, but each of these requires a foundation.

Rosettes should be sewn to the hat, if possible, through the centre, or *between* the loops or flutes.

Hat Trimming. To sew on feathers, nip off any superfluous length of wire and bend up the remainder, which should be bound with a small piece of crossway velvet to prevent the cotton slipping off the stem or wire when sewing the feathers on.

When a quill end or fancy sheath is used, do not bind the end of the feather, but slip the stem in the sheaf, and sew through the quill end or the holes in it. Tie the cotton about 2 in. from the end of the feather on the underside; leave the cotton loose for about 1½ in., and tie in position to edge of brim, or wherever it is required to fall. A feather should never be fastened tight down to the brim. When it has to be stitched to a velvet hat, first sew it to a piece of stiff net, which can be secured to the hat more firmly and with fewer stitches. A buckle, ornament, or some other kind of trimming must neaten the end in this case.

Feathers on lace or net hats are sewn to one or more wires; a piece of stiff net is placed at the back and the stitching taken through. Some feathers require to be wired down the stem, to make them retain their position. In this case use support wire, and nip round the end, making a small loop. The wire should leave off about 2 in. from the end.

Wings and quills are stitched securely at the base. Quills may even have a stitch taken through the stem, which can be done by using a No. 3 "between" needle. If wings are padded, secure them through that part. Sew the ends in position with the tie-stitch.

Jet and fancy ornaments, such as buckles, clasps, etc., must be always stitched in the centre as well as on each side, to prevent their slipping sideways.

Birds, if worn, must be firmly sewn to a wire, which is generally fixed at the back. There is so much choice in the manufactured wings and quills made from poultry feathers, neatly mounted and dyed to any colour and shape, that there is no need to use the aigrette of living birds. Such ornaments will never be worn by the woman who takes the trouble to learn at what cost these things are collected and prepared.

To stitch on flowers or wreaths, cut off any unnecessary length of stem and bend up the remainder. Stitch the flowers firmly to the hat by taking the stitches over and over from side to side of the stem and cutting off those that are not needed. Arrange the flowers and foliage in position, and tie-stitch them to hat.

A trail of flowers is caught here and there with the tie-stitch very loosely to the shape. Coloured cotton to match must be used. No stitches should show, and the trimmings should look as if they are "laid" on the hat.

Continued

TEXTILE CALCULATIONS & DESIGN

Basis of Counts. Drafting the Design. Structure of Cloth. Double Cloths. Contraction of Warp. Textile Books

By F. S. HUDSON

THIS article is the concluding one in our textile series. We then proceed to study the theory and practice of dyeing. A fitting conclusion to our textile study will be a consideration of textile calculations and a concise summary of the principles of textile design, with a list of the best textile books, which may be recommended to those who wish to pursue the subjects of textile theory and practice into detail.

Calculations. The worsted count of yarn is based on the number of hanks or lengths of 560 yd. each which weigh 1 lb. avoirdupois. This is signified by writing the number opposite the colour of the yarn—as "$^1/12$ black worsted," which means there are 12 hanks or lengths of 560 yd. each which weigh 1 lb., so there will be $560 \times 12 = 6{,}720$ yd. of yarn in 1 lb. of this material. In a yarn which was numbered $^2/24$ worsted, it would have just the same number of yards per lb. as the above yarn, because it would be composed of two threads of $^1/24$ yarn, which is equal to one thread of $^1/12$ yarn. It is written $^2/24$ to show that it contains two threads of $^1/24$ instead of being composed of one thread only. To arrive at the true count, it must be divided by the number of threads which make up the yarn—that is, $24 \div 2 = {}^1/12$ worsted.

Cotton yarn is calculated on the number of hanks or lengths of 840 yd. each which weigh 1 lb., with the same rules as apply to worsted. Yorkshire skein woollen yarn is based on the number of hanks or lengths of 256 yd. which weigh 1 lb. If 10 hanks or lengths of 256 yd. each, woollen, weigh 1 lb., it is 10-skein yarn; also, if 10 yd. of woollen yarn weigh 1 dr., it is 10-skein yarn, because 1 lb. avoirdupois contains 256 dr., and one hank of Yorkshire skein woollen yarn contains 256 yd. Spun silk yarn calculations are based on the number of hanks or lengths of 840 yd. each which weigh 1 lb., but with this important distinction, that however many threads go to compose a spun silk yarn, the count is signified by the first number. $40/^2$, $40/^3$, $40/^4$ spun silk are all the same thickness, although the first is composed of two threads, the second of three threads, and the third of four threads respectively.

Testing the Counts. For testing the counts of worsted yarn there is a small weight which weighs $12\frac{1}{2}$ gr.; this is used on delicate scales to obtain greater accuracy, and this number is obtained by dividing the number of grains in 1 lb. avoirdupois, which is 7,000, by 560, the number of yards in one hank of worsted; this is put in one of the scales and the yarn in the other. This implies that if 1 yd. of worsted is found to weigh $12\frac{1}{2}$ gr., it is 1-count worsted; similarly, if $12\frac{1}{2}$ yd. of worsted is found to weigh $12\frac{1}{2}$ gr., it is $12\frac{1}{2}$-count worsted; also, if 20 yd. of worsted is found to weigh 20 gr., it is 20-count worsted.

For testing the counts of cotton yarn the weight is $8\frac{1}{3}$ grains, obtained by dividing the number of yards in one hank, 840, into 7,000, the number of yards in 1 lb., and then tested in the same way as worsted. Yorkshire skein woollen yarn is tested by finding the number of yards which weigh 1 dr., obtained by dividing 256, the number of yards which is contained in one hank, into 256, the number of drachms in 1 lb.

Practical Calculations. The first useful calculation is that of converting a count of yarn in one denomination to an equivalent count in another denomination.

What counts in cotton is equal to $^2/24$ worsted?

$$^2/24 = {}^1/12\ \frac{560 \times 12}{840} = 8, \text{ or } ^2/16 \text{ cotton.}$$

When this is worked out, it gives the above answer. This rule applies to all the above systems. A short method of converting worsted counts into cotton counts is to multiply by 2 and divide by 3.

What is the resultant counts of 40 worsted and 20 worsted twisted together?

$$40 \div 40 = 1 \text{ lb.}$$
$$40 \div 20 = 2 \text{ lb.}$$

40 hanks weigh 3 lb. of twisted yarn, and $40 \div 3 = 13\frac{1}{3}$ counts.

If 60 lb. of twist is required composed of 40 and 20 yarn, how many lb. of each will be required to make this amount of yarn?

$$40 \div 40 = 1 \text{ lb.}$$
$$40 \div 20 = 2 \text{ lb.}$$
$$\overline{} = 3 \text{ lb.}$$

$$\frac{60 \times 1}{3} = 20 \text{ lb. of yarn of 40 counts.}$$

$$\frac{60 \times 2}{3} = 40 \text{ lb. of yarn of 20 counts.}$$

Total, 60 lb. of yarn.

To Find Weight of Warp. To enable us to do this, we shall require to know what length the warp is to be made, the ends per inch, the width in loom, and the counts of yarn.

How many lb. of yarn will it take to warp a piece warp 70 yd. long, 64 in. wide, 60 ends per inch, of $^2/24$ worsted warp and weft?

$$\frac{60 \times 64 \times 70}{560 \times 12} = 40 \text{ lb. of yarn.}$$

To find weight of weft, put picks per inch instead of ends, and take length of warp as above. This will allow for waste of weft during weaving.

The Diameter of Yarn. To find this, it is necessary to find the number of yards in 1 lb. of the yarn we want to find the diameter of, and then find the square root of this number; 10 per cent. of this number must be deducted for worsted, 8 per cent. for cotton, 16 per cent. for woollen yarns. This gives us the average diameter of the yarn.

What is the diameter of $^1/24$ worsted? This yarn will contain 560×24 yd. per lb., and the square root of this is 116, less 10 per cent. for worsted = 105, the number of ends of this yarn which can be laid side by side in 1 in. without compression, which implies that the diameter of this yarn is $\frac{1}{105}$ in.

The respective diameters of yarns will vary inversely as the square root of their respective counts.

The above calculation is useful in making cloths which have both counts of warp and weft alike, also the number of ends and picks.

To make a cloth in the above yarn with the 2—2 twill design, it would allow us to have

$$\frac{105 \times 4}{4 + 2} = 70 \text{ ends and picks per inch,}$$

because there are four ends and two intersections in this design. The diameter of the yarn is multiplied by the ends in design, and divided by the sum of ends and intersections.

COUNTS OF YARN			
Worsted.	Cotton.	Woollen.	Square Root of Yards per lb.
1	·666	2·187	23·750
2	1·333	4·375	33·500
3	2·0	6·562	41·0
4	2·666	8·750	47·356
5	3·333	10·937	52·950
6	4·0	13·122	58·0
7	4·666	15·309	62·623
8	5·333	17·500	67·0
9	6·0	19·683	71·0
10	6·666	21·875	74·8
11	7·333	24·062	78·5
12	8·0	26·244	82·0
13	8·666	28·437	85·333
14	9·333	30·618	88·695
15	10·0	32·812	91·333
16	10·666	35·0	94·333
17	11·333	37·184	97·593
18	12	39·375	100·39

Table for Reference. The useful table above gives the counts of worsted from 1 to 18, with the equivalent counts in cotton and woollen; also the square root of the yards per lb. of each count up to $\frac{1}{100}$ in. 10 per cent. must be deducted for worsted, 8 per cent. must be deducted for cotton, 16 per cent. must be deducted for woollen for the diameter of yarn. This is sufficiently accurate for all practical purposes.

Cloth Analysis. When a sample of cloth has been analysed and the design found, the amount of shrinkage in warp and weft must be estimated. This can be obtained by simple rule of three, so that if a sample contains 40 ends and picks finished, and has shrunk one-sixth, it will have $\frac{40 \times 6}{5} = 48$ ends and picks in loom.

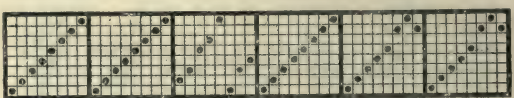
After this, there are still two more important factors to find; these are the counts of yarn used and the weight of cloth. Broadcloth is usually made 56 in. wide and 37 in. per yd. allowed finished. To find the weight of a yard of broadcloth as above, multiply 37 by 56; this gives the number of square inches in this length. When this is divided by the number of grains in 1 oz., 437½, the answer is 4·73. This number represents square inches. Now, if a piece of cloth 1 in. broad and 4·73 in. long, or 2 in. broad and 2·36 in. long weighs 16 gr., a piece of cloth 37 in. by 56 in. will weigh 16 oz. So this is a ready means of obtaining the weight of a piece of cloth by weighing a small sample, without any calculations, by simply having a piece of card cut 2 in. by 2·36 in., and placing it on a sample of cloth and cutting cloth the same size and weighing on a grain balance.

The size of card to be used for any other length and width may be obtained by the above method. After the weight has been obtained as above, the counts of yarn can be got by taking a few threads from the cloth. If we can get 12 threads, each 3 in. long, and these are weighed on a grain balance, and found to weigh 1 grain, the counts will be 12½ worsted, because, if 1 yd. weighs 1 gr., 12½ yd. will weigh $\frac{12\frac{1}{2} \times 1}{1} = 12\frac{1}{2}$ gr., which is the yarn weight for worsted. Other counts will reckon in the same proportion.

Loss in Weight. Allowance must be made for the weight the yarn has lost in finishing, and the amount which it has shrunk; sometimes these two neutralise each other. For worsted yarns, 5 per cent. is generally allowed for loss in weight, and 16 per cent. for shrinkage in length and width, according to design used and style of cloth. In woollen yarns, 10 per cent. is generally required to cover loss in weight, and 20 per cent. is sometimes allowed to cover the amount of shrinkage. In cotton yarns, 3 per cent. will often cover loss in weight and shrinkage.

Healding Calculations. These are required by healders or drawers-in. If it is required to draw a warp in to eight shafts, 64 ends per inch straight draft, 64 must be divided by 8 to find the number of mails required on each shaft, which in this case is eight.

But if a warp has to be drawn as the following draft [1] with 64 ends per inch, a different calculation is necessary, because the numbers of mails on each shaft are not all alike.



1

On the first, second, fourth, fifth, and eighth shafts there are six ends in one repeat of draft on each shaft.

On the third and seventh there are seven ends.

On the sixth shaft there are four ends.

Now, to find how many mails per inch is required on each shaft, the following calculation is necessary:

$$\frac{\text{Ends per in.} \times \text{number of ends on shaft in one repeat of draft}}{\text{Number of ends in one repeat of draft}} = \left\{\begin{array}{l}\text{Number} \\ \text{of mails}\end{array}\right.$$

$\frac{64 \times 6}{48} = 8$ mails per in. on Nos. 1, 2, 4, 5, and 8 shafts $= 40$

$\frac{64 \times 7}{48} = 9\frac{1}{3}$ mails per in. on Nos. 3 and 7 shafts $= 18\frac{2}{3}$

$\frac{64 \times 4}{48} = 5\frac{1}{3}$ mails per in. on No. 4 shaft $= 5\frac{1}{3}$

Total mails per in. .. 64

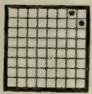
Structure of Plain Cloth. This is shown by this cross-section [2] through the warp; the dots represent ends in warp, and the line picks in weft.

2

This is represented on design paper as shown in **3**, which is complete on two ends and picks, with black squares for warp, and white squares for weft.

This design is used a great deal in the cotton trade and low woollens with cotton warp and woollen weft, and also in light-weight suitings for the warmer parts of the world. It is the simplest of all designs and can be woven on two shafts, but its structure is different from all other cloths, because each end is working opposite its neighbour, and the same with each pick, whereas in other cloths some ends

and picks are working alike in some parts of the design.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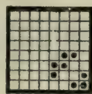
4

5

Structure of Twill Cloth. This is shown by cross-section [4], through the warp; this is 2—2 twill, and is probably the most generally used design for suitings in all the world, and is represented on design paper as in **5**.

Principles of Drafting. It is possible to get a large variety of designs on four or eight shafts with this design, when the "Principles of Drafting" are understood as explained below. If **6** design was woven in a straight draft it would take 48 shafts to weave it, because this number constitutes one repeat. By taking the ends vertically, and numbering those ends which work alike with the same number it is possible to draft it to weave on four shafts, as **7**.

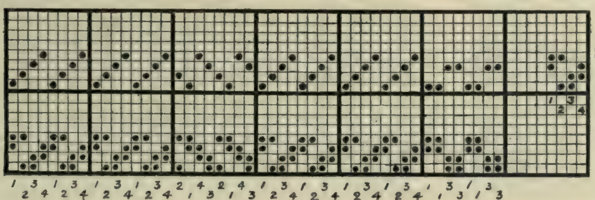
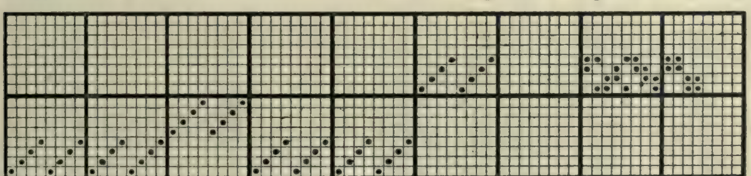

7 8 6

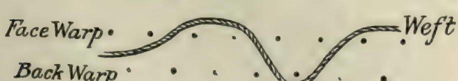
Figure **8** is the pegging plan, and is composed of the four different kinds of ends in the draft **7**.

The same result may be arrived at by drafting it as **9**, with **10** as pegging plan. The draft has the advantage of being able to weave a straight draft or a combination of small effects, as **10**.


9 10

Structure of Double Cloths. A thorough knowledge of double cloths is invaluable to the textile designer; cloths of this kind may be allowed to have both sides alike, or totally different.

The simplest kind of double cloths are those which are backed with warp, but single in weft,

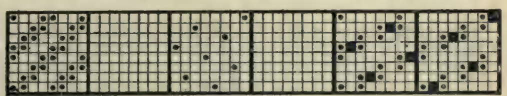


11

or vice versâ. Figure **11** is cross-section through warp of a cloth backed with warp, 2—2 twill face, eight-end sateen back. The top line of dots represents face warp, and bottom line of dots back warp, and the line represents weft.

Binding of Double Cloths. In binding cloths together with warp, a backing end should always be brought up at the point of binding between two face ends and over a face pick of weft, and so with every pick throughout the design. In all double cloths the binding point should always be concealed as much as possible; and, also, whenever possible, they should be distributed on a sateen basis.

Figure **12** is face design for above cross-section, **13** is back design for above cross-section, including binding, and **14** is face and back design combined end and end on above principles, and is complete.


12 13 14

Contraction in Weaving. A cloth made with **13** design should have two warps to weave from, one for face cloth, and one for back cloth, owing to the different contractions in weaving of face design and back design. The face weave 2—2 twill will contract about $\frac{1}{11}$th and the back weave about $\frac{1}{20}$th during weaving. So that if the face warp is made 70 yd., the back warp should be 66$\frac{2}{3}$ yd. Now, if the face warp contracts $\frac{1}{11}$th of 70, it will give 63$\frac{1}{3}$ yd. out of loom; if the back warp contracts $\frac{1}{20}$th of 70, it will give 63$\frac{1}{3}$ yd. out of loom, less 1 yd. allowed for waste in starting and for warp left in gear = 62$\frac{1}{2}$ yd. out of loom proper.

This contraction is due to the fact that in weaving it is necessary to interlace the warp with the weft at certain places throughout the design, and the more interlacing we have the less ends and picks we can get into the cloth. In the 2—2 twill there are four intersections of weft with warp in eight ends; when this is worked out in a geometrical problem, it gives the answer that 5·464 ends will occupy the space which six diameters of yarn would occupy if there were no interlacing of warp with weft. This is equal to a take-up of $\frac{1}{11}$th.

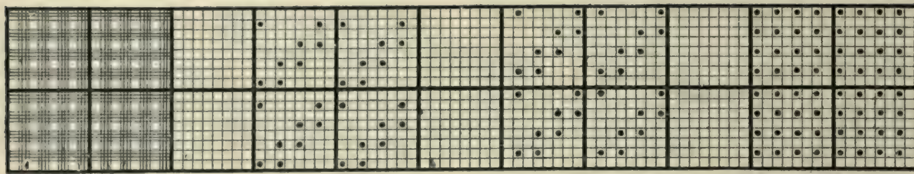
And, similarly, in the eight-end sateen, there are two intersections of weft with warp in eight ends, which gives the answer that 9·464 ends will occupy the space which 10 diameters of yarn would occupy if there were no intersecting of weft and warp. This is equal to a take-up of $\frac{1}{20}$th.

Double Cloth in Warp and Weft. To make this kind of design many designers shade their design paper as **15**; then the black squares represent the face ends and picks, and the darkest squares the backing ends and picks.

A double cloth design with the 2—2 twill face and back, and bound in the eight-end sateen order is shown complete in **20**.

First, the face weave is put on the blank squares in **16**.

Secondly, the back weave is put on the darkest squares as in **17**.



15 16 17 18

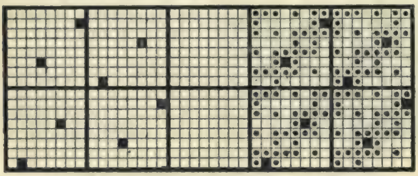
Thirdly, all the face ends are lifted up when each backing pick goes in, as in **18**.

Fourthly, the binding weave is put on as in **19**, which is the eight-end sateen.

But before this is put on, the proper place for binding must be selected to bring a backing end up between two face ends over a face pick.

These are all combined in **20**, which makes a complete double cloth design 2—2 twill face and back. This design is bound in exactly the same way as **14**, but has a backing weft added.

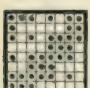
If **19** was left off **20**, there would be two separate cloths woven, one upon the other, but this is put on to bind the face and back cloths together. A sateen weave should always be used for binding, so that it gives an all-over effect instead of running in twill order.



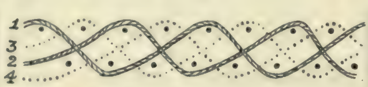
19 20

Figure **21** is the 2—2 twill face and back, bound in the four shaft twill weave, and can be woven on eight shafts. Cloths woven on either of the two designs can be woven from the warp beam, because the face ends and backing ends have practically the same intersections. Figure **21** will give a much harder cloth than **20**, because the two cloths are more firmly bound together.

Double Plain Cloth. Figure **22** is cross-section of this kind of cloth through the warp, and is bound together by every pick of weft passing from face to back and back to face; the top line of dots are face warp and bottom line of dots are back warp.



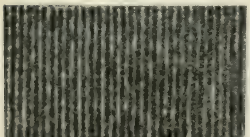
21



22

Figure **23** is design for above cross-section, and is largely used in the making of some classes of "West of England" hairline trouserings.

If a warp was made in this design and warped White 1 2 1, Black 2 2 and woven $\frac{2}{2}$ it would show unbroken lines of white and black running the length of the piece alternately on both face and back of cloth, and the cloth is also very firmly bound.



24

A sample of this cloth is shown in **24** in grey and black.

Two-face and One-back Cloths. A large variety of lined cloths is made for overcoatings with the 2—2 twill face and plain design for lining, with two ends and picks of face to one end and pick of backing; the back can be made plain, striped, or checked, without interfering with the face cloth. Figure **25** is a cross-section through warp with a face pick.

25

Figure **26** is the design for this if woven in a straight draft on 24 shafts, and is made in the same way as **20**. The dots outside the design indicate which are the backing ends and picks; this kind of design is generally begun—one face, one back, one face, in both warp and weft.

If it is required to make this design on less than 24 shafts, it can be drafted on to 16 shafts by putting face weave on the first eight shafts and back weave on last eight shafts, as in **26** draft, with **27** as pegging plan.

The same rules must be observed in this design as when making **20** design. Figure **26** is also bound in the eight-end sateen order [**19**].

Overcoating Cloth. A good medium-weight overcoating cloth can be made with this design to the following particulars, 72 ends and picks per inch, 66 in. wide in loom, one beam.

FACE WARP.

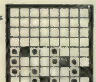
White and black twist worsted 2/36	1	1	1	1	1	1	1	1	=48
Black worsted 2/36	3	3	3	3	7	7	7	7	

BACK WARP.

White spun silk 18/2 ..	1		1		1		1		1		1	=48
Black worsted 2/36 ..	1	1	1	1	1	15	1	1	1	1	15	
Blue spun silk 18/2 ..	1		1									
Green spun silk 18/2 ..							1		1			

Weft. 24 Skeins Black Woollen Y.S.

This will give a neat stripe effect on the face cloth and a fancy striped lining with silk ends for striping, while the face cloth and lining will be bound securely together during weaving.



23

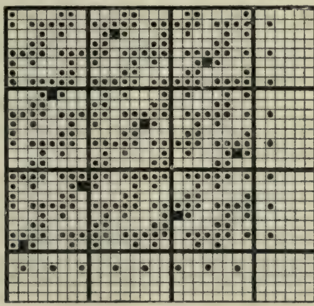
All students in the textiles should study various branches of it, because it frequently happens that they sometimes see things in other branches which they can make useful to them in their own branch of the trade. A student of decorative textiles will often derive great benefit by visiting an art exhibition both for design and colour; similarly, a student in the woollen and worsted trades may often learn something by examining samples of the fancy cotton trade.

The designer, manager, and those who assist them should all work in harmony to seize all the advantages of all branches of the trade in getting new ideas, making the proper article for the proper market, and in using the best machinery and the best method of making what is required. Before beginning to make the patterns, the traveller, designer, and assistants should consult together as to what is to be made, and when they have settled

what to make they should all try to make something better than has been made before, but always remembering the proper service for which it is made, and to get it in the proper market and at the proper time, not too late and not too soon.

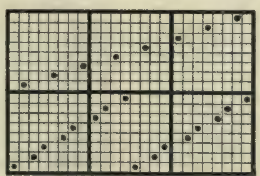
Requirements of a Designer. The textile designer must have a good knowledge of calculations and colour, and remember that ideas beget ideas, and also that his present knowledge must forge the links of connection between what has been already accomplished and what is now required.

He should be a keen observer, because in the field of observation chance favours only those who are prepared; and, lastly, he should possess self-reliance, fertility of resource, fearlessness of responsibility, and the power of his own initiative, and be able to apply all the best points of his education in his daily work.



26

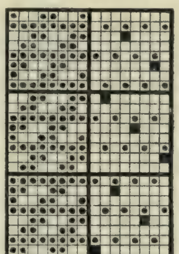
A large quantity of patterns for showing purposes are still produced in the hand looms of Yorkshire, owing to the fact that no box-chain is required for patterns which are checked with weft, as this is done by the weaver as he goes on with his work. Of late years there have been many improvements in looms for fancy weaving in suitings; and the year 1906 has been the advent of the new Dobeross loom, made by Hutchinson, Hollingworth & Co., which runs at the rate of 100 picks a minute. There are now hundreds of these looms running in the West Riding of Yorkshire which are doing their work wonderfully well. There is still room for improvement in the finishing machinery because the required finish cannot always be got the first time goods are finished. When this is the case the work has to be gone through again, causing inconvenience and expense.



27

Textile Books. The following list of books is useful for students in the various branches of the textile trade:

"Colour in Woven Design," by R. Beaumont (Whittaker. 21s.); "Woollen and Worsted Cloth Manufacture," by R. Beaumont (Whittaker. 7s. 6d.); "Cotton Spinning," by R. Marsden (Whittaker. 6s. 6d.); "Cotton Weaving," by R. Marsden (Marsden, Manchester. 10s. 6d.); "Pattern Analysis," by A. F. Barker (Marsden. 5s.); "Cotton Spinning Calculations," by W. H. Cook (Marsden. 2s.); "Colour," by G. H. Hurst (Marsden. 7s. 6d.); "Neville's Student's Handbook of Practical Fabric Structure," by Neville (D. W. Bardsley, Oldham. 5s.); "Stephenson and Suddard's Ornamental Design in Woven Fabrics," by Stephenson and Suddard (D. W. Bardsley. 6s. 2d.); "Calculations in Yarns and Fabrics," by F. Bradbury (F. King & Sons, Halifax. 3s. 6d.); "Carpet Weaving," by F. Bradbury (King. 10s. 6d.); "Worsted Overlooker's Handbook," by M. M. Buckley (King. 1s.); "Cone Drawing," by M. M. Buckley (King. 1s.); "Weaving Problems," by T. Oliver (W. & J. Kennedy, Hawick. 2s.); "Chevreul on Colour," by M. E. Chevreul (Bell & Sons. 7s. 6d.); "Design in Textile Fabrics," by T. R. Ashenhurst (Cassell. 4s. 6d.); "Spinning Woollen and Worsted," by W. S. B. McLaren (Cassell. 4s. 6d.); "Weaving and Designing of Textile Fabrics," by T. R. Ashenhurst (J. Broadbent & Co., Huddersfield. 12s. 6d.); "Treatise on Textile Calculations and Structure of Fabrics," by T. R. Ashenhurst (Broadbent. 5s.); "Practical Weaving and Cloth Dissecting," by T. R. Ashenhurst (Broadbent. 15s.); "The Mechanism of Weaving," by T. W. Fox (Macmillan. 7s. 6d.); "Woollen Spinning," by C. Vickerman (Macmillan. 6s.); "Cotton Spinning," by W. Scott Taggart (Macmillan. Vol. I. and II., 4s. each; Vol. III., 10s.); "The Jacquard Machine," by E. A. Posselt (Emmot & Co., Manchester. 15s.); "Flax, Tow, and Jute Spinning," by P. Sharp (Emmot. 5s.); "The Structure of Fibres, Yarns, and Fabrics," by E. A. Posselt (Emmot. 42s.).



Face *Back*

28

Textile Classes. Many students attend the technical classes in textile manufacturing towns in Yorkshire and Lancashire. The Yorkshire schools are mostly devoted to woollen and worsted, while those in Lancashire concern themselves with cotton. Leeds University is probably the finest equipped textile school in the world, and contains the required machinery for all the processes from the raw material to the finished cloth. The technical schools of Halifax, Bradford, and Huddersfield are also well equipped, although not to the extent of Leeds. Generally, they have both day classes and evening classes. The latter are attended by persons who work in the daytime who desire to improve their textile knowledge and take up more important positions. A student should be well grounded in arithmetic before he attends these classes; otherwise he will be much hindered in his work.

A student attending the day classes should have two or three years of practical work in a mill. He can then combine the best points of school knowledge with the best practical knowledge gained in the mill. If he has not had this practical experience he may make serious mistakes when he has taken a position outside the school. The students in the spinning department have the facilities of putting their theoretical knowledge into practical certainty on the machinery, making their own calculations and setting the machines accordingly, while the teacher puts them right and explains any errors. They are then accepted for examination in practical work by the City and Guilds of London. The courses are for three or four years, with examinations at the end of each year, when certificates are awarded to those who pass. The International Correspondence Schools of 57–60, Chancery Lane, London, W.C., have now a textile correspondence department.

TEXTILES *concluded; followed by* DYEING

FRENCH—SPANISH—ESPERANTO—GREEK

French by Louis A. Barbé, B.A.; Spanish by Amalia de Alberti and H. S. Duncan; Esperanto by Harald Clegg; Greek by G. K. Hibbert, M.A.

FRENCH

Continued from page 5373

By Louis A. Barbé, B.A.

THE ARTICLE—continued

Agreement of the Article

1. The article agrees in gender and number with the noun which it precedes: *Le cœur, l'esprit, les mœurs, tout gagne à la culture,* the heart, the mind, manners, everything is improved (gains) by culture.

2. The plural article *les* is occasionally used before a proper noun in the singular, merely for the sake of emphasis, and without reference to more than one person of the same name: *Les Corneille, les Racine et les Molière ont illustré la scène française,* Corneille, Racine, and Molière have made the French stage illustrious.

3. The feminine article *la* is used before a saint's name in the masculine, to indicate the day on which that saint's feast is celebrated. In that case, the article agrees with the word *fête* understood: *Je vous payerai à la Saint-Michel prochaine,* I shall pay you next Michaelmas.

4. The feminine article is used before a masculine noun—generally a proper noun—to indicate some special fashion or manner. The word *mode* or *manière* is then understood, and the article agrees with it: *Il a la barbe taillée à la Henri IV.,* His beard is cut after the fashion of Henry IV.

Repetition of the Article

1. The article, whether definite or indefinite, must be repeated before every substantive: *Il a les traits, les regards et la démarche de son père,* He has the features, looks, and demeanour of his father.

2. The use of a single definite article in the plural is customary in certain cases where two or more nouns form an indivisible expression, or unite to constitute a single, definite collection: *École des Arts et Métiers,* School of Arts and Trades. *Les officiers, sous-officiers et soldats,* the officers, non-commissioned officers, and men.

3. When nouns are joined by the conjunction *ou* (or), each of them requires the article, unless the second be synonymous with the first, or an explanation of it: *Le père ou le fils nous écrira demain,* The father or the son will write to us to-morrow. *Les collines ou petites montagnes sont couvertes d'arbres,* The hills or small mountains are covered with trees.

4. When several adjectives joined by *et* refer to the same noun, the article must be used before each of them if the noun indicates several persons or objects: *Les riches et les pauvres seront tous jugés selon leurs œuvres,* The rich and poor will all be judged according to their works.

5. If the several adjectives qualify the same person or object, one article only is required: *Je viens de finir le troisième et dernier volume de ce roman,* I have just finished the third and last volume of that novel.

Ellipsis of the Article

1. The article is frequently omitted in proverbial expressions:

Patience et longueur de temps
Font plus que force ni que rage;
Patience and perseverance (length of time)
Achieve more than strength or fury.

NOUNS

I. Nouns of Double Gender

1. There are a few substantives which are either masculine or feminine, with a modification, or only a slight difference of meaning:

(*a*) AMOUR, love, is usually masculine, both in the singular and the plural: *L'amour du jeu réunit tous les autres amours,* The love of gambling comprises all other passions (loves).

In the plural it is feminine when used to designate the passion of love, in the more restricted sense, and when used as "amours" in English. *On retourne toujours à ses premières amours,* We always return to our first love.

(*b*) COUPLE, couple, is masculine when it is applied to two persons between whom their exists a bond of sentiment, similarity of object, etc. It is feminine when meaning simply two, a brace: *Ce serait dommage de séparer un si beau couple,* It would be a pity to separate such a handsome couple. *Une couple d'œufs suffira pour mon déjeuner,* A couple of eggs will suffice for my breakfast.

(*c*) DÉLICE, delight, pleasure, is masculine when used in the singular, and feminine when used in the plural. The meaning is practically the same in both instances: *C'est un grand délice de faire des heureux,* It is a great pleasure to make people happy.; *Il fait toutes ses délices de l'étude,* He makes study his whole delight.

(*d*) FOUDRE, thunderbolt, is feminine when used in its literal sense, and masculine when applied figuratively to a great warrior or a great orator. *Cet arbre a été frappé de la foudre,* That tree has been struck by a thunderbolt (lightning). *On dit, au figuré, un foudre de guerre, un foudre d'éloquence, pour désigner un guerrier à qui rien ne résiste, un orateur véhément,* We say, figuratively, *un foudre de guerre, un foudre d'éloquence,* to designate a warrior whom nothing can withstand, a vehement orator.

(*f*) HYMNE is feminine when it means a church hymn, and masculine in any other sense: *Les anciennes hymnes de l'Église ont le mérite de la simplicité,* The old hymns of the Church have the merit of simplicity; *Chaque peuple a son hymne national,* Every nation has its national anthem.

(*g*) ŒUVRE, work, is usually feminine. It is sometimes masculine in poetical language, or when it has the special meaning of "the search for the philosopher's stone" or of the collected works of an engraver or of a composer: *Ce volume contient les œuvres complètes de Corneille,* That volume contains the complete works of Corneille.

(*h*) GENS, people, requires words in agreement with it to be feminine if they precede and masculine if they follow it: *Ce sont les meilleures gens que j'aie jamais vus,* They are the best people I have ever seen.

But words in agreement with *gens* are always masculine, if they occur in a separate clause, whether before or after it: *Instruits par l'expérience toutes*

les vieilles gens sont soupçonneux, Taught by experience, all old people are suspicious.

"All" must be translated by the masculine form *tous* when it accompanies an adjective having but one form for both genders and preceding *gens*: *Tous les honnêtes gens,* all honest people.

Tous must also be used, even when it precedes *gens,* if *gens* is followed by an adjective or past participle: *Tous les gens sensés,* all sensible people.

2. The following nouns have a different meaning according as they are of the masculine or of the feminine gender:

aide (m.), a person who helps
aide (f.), help, assistance
aune (m.), alder-tree
aune (f.), ell
cerise (m.), cherry-colour
cerise (f.), cherry
crêpe (m.), crape
crêpe (f.), pancake
critique (m.), critic
critique (f.), criticism
enseigne (m.), ensign, standard-bearer
enseigne (f.), standard, signboard
faux (m.), forgery
faux (f.), scythe
fourbe (m.), rogue
fourbe (f.), imposture
greffe (m.), record office (of a court of law)
greffe (f.), grafting
guide (m.), guide
guide (f.), guiding-rein
livre (m.), book
livre (f.), pound
manche (m.), handle
manche (f.), sleeve;
Manche (f.), Engl. Channel
manœuvre (m.), workman, mechanic
manœuvre (f.), manœuvre
martyre (m.), martyrdom
martyre (f.), female martyr
mauve (m.), mauve colour
mauve (f.), marsh-mallow
mémoire (m.), memoir, bill
mémoire (f.) memory
mode (m.), mood, manner
mode (f.), fashion
mort (m.), dead man
mort (f.), death
moule (m.), mould, model
moule (f.), mussel (shell-fish)
mousse (m.), cabin-boy, ship-boy
mousse (f.), moss
office (m.), office, service, functions
office (f.), pantry, servants' hall
orange (m.), orange colour
orange (f.), orange
page (m.), page (attendant)
page (f.), page (of a book)
paillasse (m.), clown
paillasse (f.), straw mattress
paille (m.), straw-colour
paille (f.), straw
parallèle, (m.) parallel (comparison)
parallèle (f.), parallel line
pendule (m.), pendulum
pendule (f.), timepiece
physique (m.), the physique of a person
physique (f.), physics, natural philosophy
pique (m.), spade (a suit of cards)
pique (f.), pike
poêle (m.), stove, pall, canopy
poêle (f.), frying-pan
politique (m.), politician
politique (f.), politics, policy
poste (m.), post, situation, guard-house
poste (f.), letter-post, stage-post
rose (m.), rose-colour, pink
rose (f.), rose
solde (m.), balance of an account
solde (f.), pay (military)
somme (m.), nap, sleep
somme (f.), sum, total
tour (m.), turn, circuit, trick, lathe
tour (*f*), tower
trompette (m.), trumpeter
trompette (f.), trumpet
vapeur (m.), steamer
vapeur (f.), vapour, steam
vase (m.), vase, vessel
vase (f.), ooze, mud
voile (m.), veil
voile (f.), sail

II. Compound Nouns

1. Compound nouns written without a hyphen are considered single words, and form their plural according to the general rules: *un chèvrefeuille,* a honeysuckle plant; *des chèvrefeuilles,* honeysuckle plants.

Exception: In the following words, the components, though not joined by a hyphen, both take the plural form:

un bonhomme, an old fellow, etc.; *des bonshommes,* old fellows, etc.

un gentilhomme, a nobleman; *des gentilshommes,* noblemen.

monseigneur, my lord; *messeigneurs,* my lords. And similarly, *monsieur, messieurs; madame, mesdames; mademoiselle, mesdemoiselles.*

2. When a compound noun consists of two nouns joined by a hyphen, both the components take the mark of the plural:

un chou-fleur, a cauliflower; *des choux-fleurs,* cauliflowers.

un oiseau-mouche, a humming-bird; *des oiseaux-mouches,* humming-birds.

un timbre-quittance, a receipt-stamp; *des timbres-quittances,* receipt-stamps.

un timbre-dépêche, a telegraph-stamp; *des timbres-dépêches,* telegraph-stamps.

Exception: In the following compound words, the first of the components is the only one that takes the mark of the plural:

appui(s)-main, maul-stick, rest for the hand; *hotel(s)-Dieu,* hospital; *reine(s)-claude,* greengage; *timbre(s)-poste,* postage-stamp; *mandat(s)-poste,* post-office order.

3. When a compound noun consists of two nouns joined by a preposition, the first noun alone takes the sign of the plural:

un arc-en-ciel, a rainbow; *des arcs-en-ciel,* rainbows.

un chef-d'œuvre, a masterpiece; *des chefs-d'œuvre,* masterpieces.

un cul-de-jatte, a cripple; *des culs-de-jatte,* cripples.

Exception: In the following words, the sense requires both components to remain invariable, even when the whole compound is in the plural:

un (*des*) *coq-à-l'âne,* a rambling story; *un* (*des*) *pied-à-terre,* temporary quarters; *un* (*des*) *pot-au-feu,* broth; *un* (*des*) *tête-à-tête,* private interview.

4. When a compound consists of a noun and an adjective, both components take the sign of the plural:

une eau-forte, an etching; *des eaux-fortes,* etchings.

un coffre-fort, a strong-box; *des coffres-forts,* strong-boxes.

une claire-voie, lattice, wicket; *des claires-voies,* lattices, wickets.

Exception: The second component alone takes the sign of the plural in (*a*) all the feminine words consisting of *grand'* and a noun, as *grand'mère,* grandmother, *grand'mères,* grandmothers; and in (*b*) the three words *chevau-léger,* a light horseman, *terre-plein,* an earthern platform or terrace, and *sauf-conduit,* a safe-conduct, of which the respective plurals are: *des chevau-légers, des terre-pleins,* and *des sauf-conduits.*

5. In compound nouns made up of a verb and of a noun, only the noun can take the sign of the plural:

un passe-port, a passport; *des passe-ports,* passports.

NOTE. In compound nouns of this kind, it frequently happens that the noun-component (*a*) remains in the singular when the whole compound is in the plural, or (*b*) is in the plural whether the whole compound be in the singular or in the plural:

(*a*) *un abat-jour,* a lamp-shade
des abat-jour, lamp shades
un casse-cou, a break-neck place
des casse-cou, break-neck places
un coupe-gorge, a cut-throat place, den
des coupe-gorge, cut-throat places, dens
un porte-monnaie, a purse
des porte-monnaie, purses
un réveille-matin, an alarum
des réveille-matin, alarums

(*b*) *un brise-lames*, a breakwater
des brise-lames, breakwaters
un porte-clefs, a turnkey
des porte-clefs, turnkeys
un serre-papiers, a paperweight
des serres-papiers, paperweights
un casse-noisettes, a nut-cracker
des casse-noisettes, nut crackers
un porte-lettres, a letter-rack
des porte-lettres, letter-racks
un couvre-pieds, a foot-coverlet
des couvre-pieds, foot-coverlets

There are, however, some cases in which the analysis of the word may be made to justify either the singular or the plural form of the noun-component, and we find authorities giving both *un porte-plume*, a penholder, *des porte-plume*, penholders, and *un porte-plumes*, *des porte-plumes*.

6. When *garde* is the first part of a compound word, it usually takes the sign of the plural if it denotes a person: *une garde-malade*, a sick-nurse; *des gardes-malades*, sick-nurses.

If it denotes an object, it commonly remains invariable: *une garde-robe*, a wardrobe; *des garde-robes*, wardrobes.

7. In compound nouns consisting of an adverb and a noun, or of a preposition and a noun, the noun usually takes the mark of the plural:

une arrière-petite-fille, a great-granddaughter; *des arrière-petites-filles*, great-granddaughters.

un avant-coureur, a fore-runner; *des avant-coureurs*, fore-runners.

un contre-amiral, a rear-admiral; *des contre-amiraux*, rear-admirals.

8. When a compound noun is made up of invariable words—*i.e.*, verbs, numerals, prepositions, adverbs—the components remain unchanged:

un passe-partout, a master-key; *des passe-partout*, master-keys.

un in-douze, a duodecimo; *des in-douze*, duodecimos.

III. Proper Nouns

1. Names of persons do not usually take the sign of the plural: *Les deux Corneille étaient frères*, the two Corneilles were brothers.

Exceptions: (*a*) When a proper noun is used to indicate, not one person, but several persons resembling the bearer of that name, the proper noun takes the sign of the plural: *Un Auguste aisément peut faire des Virgiles*, An Augustus can easily produce Virgils—*i.e.*, poets like Virgil.

(*b*) Proper nouns common to a whole race, dynasty, etc., take the sign of the plural: *Deux des Stuarts ont péri sur l'échafaud*, Two of the Stuarts perished on the scaffold.

(*c*) When the name of an author or of a painter is used to indicate copies or examples of his works, it is treated as a common noun, and takes the sign of the plural accordingly: *J'ai plusieurs Virgiles dans ma bibliothèque*, I have several Virgils in my library.

2. Proper names of countries take the sign of the plural: *Nous avons visité les Indes occidentales et les deux Amériques*, We have visited the West Indies and the two Americas (North and South).

IV. Foreign Nouns

1. Foreign words that have become naturalised as French nouns, form their plural in the usual way: *Un accessit*, an honourable mention; *des accessits*, honourable mentions; *un tory*, a Tory; *des torys*, Tories.

2. Most Latin compounds used in French are invariable: *un post-scriptum*, a postscript; *des post-scriptum* postscripts; *un ex-voto*, a votive offering; *des ex-voto*, votive offerings.

3. Prayers, hymns, etc., are frequently indicated by their Latin beginning, which remains invariable when used as a plural noun: *un Te Deum*, a Te Deum; *des Te Deum*, Te Deums.

KEY TO TRANSLATION

GEOGRAPHY OF THE FRENCH LANGUAGE

The French language comprises the whole domain of modern France, with the exception of a single province, Brittany, where a million inhabitants out of 1,800,000 speak a language known under the name of Low Breton (and) which is of Celtic origin. To this important exception we may add further three little groups—the Department of the North, where 200,000 inhabitants (out of 1,200,000) speak the Flemish language, which is of German origin; the Department of the Lower-Pyrenees, where 120,000 inhabitants speak Basque, a very ancient dialect, of which the origin is unknown; finally, the Department of the Eastern-Pyrenees (the former province of Roussillon), where 130,000 inhabitants speak the Catalonian language, which is derived from Latin.

If the domain of the French language does not extend over the whole of the present territory of France, by way of compensation it comprises abroad several important territories, representing a little more than 3,600,000 inhabitants, divided thus: for Belgium, 1,600,000 inhabitants; for the Empire of Germany, 1,000,000 (Alsace-Lorraine); for French Switzerland, 400,000; lastly, 60,000 for the Channel Islands, which belong to England.

To these figures there must be added, outside of Europe, the English colonies of Canada and of the Island of Mauritius, which have retained the use of French, without speaking of our own colonies (Algeria, Guiana, Senegal, etc.). This is a balance of rather more than 1,500,000 to be added to the French linguistic domain.

Continued

SPANISH Continued from page 5231 By Amalia de Alberti & H. S. Duncan

Familiar Dialogues	Dialogos Familiares
Who knocked at the door?	¿ Quien ha llamado á la puerta ?
The countess's footman, with a note	El lacayo de la señora condesa con una esquela
Bring it here	Traígala
He will not deliver it excepting into your own hands	No quiere sino entregarla en manos propias
Show him in	Hágale pasar
Good-day, madam	Buenos dias, señora.
How are you?	¿ Como esta Vd ?
Middling. Sit down	Regular, tome Vd asiento

Thanks. I came to say good-bye. I am leaving to-morrow for Paris	Gracias. Vengo á despedirme; salgo mañana para Paris
Are you going alone? Is not your wife going with you?	¿ Va Vd solo? No va su Sra. con Vd?
No; her health does not permit it	No; su salud no se lo permite
I am very sorry	Lo siento mucho
How pleased I am that you have called at this hour. Now that you are here, you will stay and dine with us?	Cuanto me alegro verle llegar á esta hora. ¿ Ahora que está Vd aquí se quedará á comer con nosotros?
I appreciate the invitation, but I cannot accept it. If you were alone it would not matter, but I really cannot sit down to table with the marchioness in these clothes	Agradezco la invitacion pero no puedo aceptarla. Si estuviera Vd solo no importaría pero en verdad no puedo sentarme á la mesa con la señora marquesa en este traje
What does it matter, man! My wife will excuse you	¡ Hombre, que importa! Mi señora dispensará á Vd
Is the post in?	¿ Ha llegado el correo?
Yes, sir. Here are the letters. It seems that the post is only for circulars and advertisements. I have four here	Si, señor. Aqui están las cartas. Parece que no viene el correo mas que para traer circulares y anuncios, aqui tengo cuatro
Where is the secretary?	¿ Donde está el secretario?
We have a great deal to write; it is mail day	Tenemos mucho que escribir; es dia de correo
What day of the month is it?	¿ A cuanto estámos del mes?
Address these letters; these four must be sealed. The sealing-wax is in that box with the stamps	Dirija estas cartas; estas cuatro necesitan sellarse. El lacre está en aquella caja, con los sellos de correo
Breakfast is served, madam	Señora el almuerzo está servido
Tell the master	Avise al amo
He is in the dining-room, and the young lady and young gentleman have also come down	Está en el comedor, y tambien han bajado la señorita y el señorito
Good-morning, mother	Muy buenos dias madre
Good-morning, children	Muy buenos dias hijos
What have we for breakfast?	¿ Que tenemos para almorzar?
In this dish here there are eggs and ham, and over there are kidneys, which look very good, and there is cod in front of Papa	Aqui en esta fuente hay huevos y jamon, y allá hay riñones que parecen estar muy buenos y delante de papá hay merluza
What will you take, chocolate or coffee?	¿ Que vas à tomar chocolate ó café?
I will take tea	Tomaré té
Where shall we go to-day?	¿ Donde irémos hoy?
We have to go to the dressmaker and to the milliner, and then we will go for a walk until it is time to fetch your father from the office, and I suppose you remember that to-night there is the ball at the Embassy	Tenemos que ir á la costurera, y á la modista, y despues irémos á dar un paseo hasta que sea hora de ir á buscar á tu padre á la oficina, y yá supongo que no te olvidas que esta noche es el baile de la Embajada
Of course, I remember	Porsupuesto que me acuerdo
Give me two first-class tickets to Z. I am going to register the luggage. Be quick so as to get a seat near the door	Déme Vd dos billetes para Z. de primera clase. Voy á facturar el equipaje. Darse prisa para coger un asiento de portezuela
I want to be with my face to the engine, otherwise, as you know, I get giddy	Quiero ir de cara á la locomotora; ya sabes que de otro modo me mareo
At the next station we will buy a small basket of provisions, what the English call a lunch basket	En la proxima estacion comprarémos una canastita con provisiones, lo que llaman los ingleses "a lunch basket"
They told me that before reaching Z. we have to pass through a tunnel	Me dijeron que antes de llegar á Z. teniámos que pasar por un túnel
Yes, and we have already reached it, but we shall soon come to the other end, and at the same time to the stopping place	Si, y ya hemos llegado a él, pero pronto llegarémos al otro lado, y al mismo tiempo al apeadero
And shall I find what I require at this office?	¿ Y encontraré alli lo que necesito?
It is possible, but it is difficult to find good servants	Puede ser, pero el encontrar buenos criados es muy dificil

COMMERCIAL PHRASEOLOGY AND VOCABULARY — FRASEOLOGIA COMERCIAL Y VOCABULARIO

The market is gradually giving way	El mercado baja gradualmente
The prospects for almonds this year are not favourable	Nada favorable es el aspecto que presentan las almendras este año
Prices for coffee are easier	Los precios para el café han cedido algo
The market is very depressed	El mercado está muy abatido ó flojisimo
A fall is not to be expected	No es de esperar una baja
More attention is paid at the present moment to other articles	En la actualidad se fija principalmente la atencion en otros articulos
A small lot has been disposed of at high prices	Se acaba de colocar un pequeño lote á precios altos
The market closes firmly	El mercado cierra firme
A few transactions have been effected at somewhat low prices	Algunas operaciones se han efectuado à tipos algo bajos
The steamer sailed last week for America, carrying a big cargo	El buque salió para America la semana pasada conduciendo un cargamento grande
Our neighbouring markets have been affected by the decline	La baja ha dejado sentir su influencia en los mercados inmediatos ó vecinos
We are completely bare, without any stock	Nos encontramos desprovistos, limpios de existencias
Our market is glutted with pears	Nuestro mercado está abarrotado de peras

What little is left unsold is eagerly bought	Lo poco que queda disponible se compra con afán
Some fresh supplies have appeared in the market	Hemos vuelto à tener nuevas entradas ó arribos
We had to force sales, and this had a bad effect all round	Nos vimos precisados à forzar ventas y el efecto en general fué adverso
It is rumoured that a well-known and long-established firm of our city is in difficulties	Corren rumores de que una casa de años establecida en nuestra ciudad, y bien conocida, se halla en dificultades
There are still some wants to be supplied	Hay aun algunas necesidades por cubrir
It is an article very highly thought of in our city	Es un articulo muy apreciado en nuestra plaza
A house is in treaty for a parcel of nuts	Una casa tiene pendiente de trato una partida de avellanas
Contracts for February delivery have been made	Se han hecho algunas contratas para entrega en Febrero
Retail sales	Ventas al detalle
The expected improvement has not yet taken place	La mejora esperanzada no se ha realizado todavia
This state of things is against business being done	Este estado de cosas entorpece las operaciónes
Business is reviving	Los negocios van cobrando vida
A considerable excitement has prevailed during the last fortnight	Ha reinado muchisima agitacion durante la ultima quincena
This invoice has not yet been paid	Esta factura no está aun pagada
Silver is quoted at a very low figure to-day	El valor de la plata hoy dia es muy bajo
The doubtful state of things	El estado dudoso ó incierto de cosas
This is an auction day	Este es dia de subasta
It is impossible to execute orders all at once	No es posible cumplimentar en el acto, todas las ordenes
We are inclined to believe that prices have reached their minimum	Creemos que los precios han visto ya su minimum

The letter-box	El buzon
The Custom House	La Aduana
The bank	El banco
A promissory note	Un pagaré
The packages	Los bultos ó paquetes
The cash-box	La caja de fondos
The warehouse	El almacen
The red ink	La tinta roja
The book-keeper	El tenedor de libros
The gum-pot	El pote de la goma
The message	El recado
The trade mark	La marca de fábrica
The workshop	El taller
The appointment	La cita
The clerk	El dependiente
The telephone	El teléfono
The telephone exchange	La central
The lift	El ascensor

Key to Exercise XXI. (1)

1. Mas vale tarde que nunca, pero mas vale pronto que tarde. 2. Les mandé dinero para que pudieran costearse el viaje, y á menos que lo reciban á tiempo, temo que no tendrémos el gusto de verlos. 3. Bien que le advertí que la especulacion era arriesgada, metió grandes sumas en esa empresa, y en caso que haga bancarrota, tendré que salir garante, puesto que es mi hermano. 4. ¿ Hola amigo, como va ? Hace tiempo que no le he visto. 5. Ya que no quiere Vd venirme á ver, aqui estoy yo, por aquello que se dice que si la montaña no viene á Mahoma, Mahoma viene á la montaña.

Key to Exercise XXI. (2)

1. That man is very tall—too tall, in my opinion. He is almost a giant. 2. Napoleon was a great man, in spite of being of small stature. 3. Playing the harp hurts the tips of one's fingers. 4. He was a man of learning. He held a chair in the University of Salamanca, and was considered the first professor of that celebrated University. 5. He occupied a very high position ; he raised himself from nothing. He was the only one who raised his voice in the defence of the freedom of the Press. 6. After the war the troops made their entrance into the capital amid the great acclamations of the people, and they are going to erect a statue to the general. 7. Mr. So-and-so was irritated this morning. Who is Mr. So-and-so ? I never remember his name.

Continued

ESPERANTO

Continued from page 5374

By Harald Clegg

Pronouns, Adjectives and Adverbs

The student is advised not to attempt to learn the following table by heart as it stands, but to make himself master of the nine distinctive terminations, as shown in column 1, each of which, it will be observed, is carried through the horizontal line quite regularly. Then the powers of the four prefixed parts, *t'*, *k'*, *ĉ'*, and *nen'*, as given in the headings of columns 2, 3, 4, and 5, should be learned so that these may be added to any of the indefinite words in column 1 according to need. Finally the meaning will be readily retained on reading sentences where they occur.

The words in line A, being adjectives, and those in line J, being pronouns, take, if required, the plural and the accusative. Those in line G are essentially pronouns, and, being of a collective character, are always singular, but may, of course, take the accusative.

The five adverbs in line D may also, when motion or direction is indicated, take the final N.

In column 2, the words *tia*, *tie*, *tio*, *tiu* may each have the word *ĉi* placed either before or after them, according to taste. This has the effect of bringing nearer the thing or place.

Example : *Tia*, that kind of ; *tia ĉi*, this kind of ; *tiaj ĉi*, these kinds of.

Tie, there ; *tie ĉi*, here ; *tien*, in that direction ; *tien ĉi*, in this direction.

Tio, that thing ; *tio ĉi*, this thing.

Tiu, that one ; *tiu ĉi*, this one ; *tiuj ĉi*, these.

The primary words are here shown with their correlatives.

ia *ĉia* } *kia*
tia *nenia*

TABLE OF CORRELATIVE PRONOUNS, ADJECTIVES, AND ADVERBS.

		INDEFINITE (1)	DEMONSTRATIVE (2)	RELATIVE AND INTERROGATIVE (3)	COLLECTIVE AND DISTRIBUTIVE (4)	NEGATIVE (5)
A	Quality	*ia* some kind	*tia* that kind, such	*kia* which kind	*ĉia* every kind	*nenia* no kind
B	Motive	*ial* for some reason	*tial* for that reason; therefore	*kial* for which reason; why?	*ĉial* for every reason	*nenial* for no reason
C	Time	*iam* at some time	*tiam* then	*kiam* when	*ĉiam* always	*neniam* never
D	Place	*ie* somewhere	*tie* in that place; there	*kie* in which place; where	*ĉie* everywhere	*nenie* nowhere
E	Manner	*iel* somehow	*tiel* thus; so	*kiel* how; as	*ĉiel* every way	*neniel* nohow
F	Possession	*ies* someone's	*ties* that one's	*kies* whose	*ĉies* everyone's	*nenies* no one's
G	Thing	*io* something	*tio* that (thing)	*kio* which (thing) what ,,	*ĉio* everything	*nenio* nothing
H	Quantity	*iom* somewhat; a little	*tiom* as much; as many	*kiom* how much how many	*ĉiom* all	*neniom* none
J	Individual	*iu* some one	*tiu* that one	*kiu* which, who	*ĉiu* each one	*neniu* no one

Example: *Mi deziras tiajn, kiaj estas miaj,* I want such as are mine.

iam ĉiam
tiam neniam } *kiam*

Example: *Li salutas ĉiam, kiam li vidas min,* He always salutes when he sees me.

ie ĉie
tie nenie } *kie*

Example: *Si loĝas tie, kien mi nun iras,* She lives there, where I am now going.

iel ĉiel
tiel neniel } *kiel*

Example: *Li laboras neniel, kiel vi volas,* He works not at all (nohow) as you wish.

io ĉio
tio nenio } *kio*

Example: *Jen estas io, kion vi bezonas,* Here is something that you want.

tiom = *kiom*

Example: *Mi prenos tiom, kiom vi posedas,* I shall take as much as you possess.

iu ĉiu
tiu neniu } *kiu*

Example: *Si dankis ĉiujn, kiuj estis tie,* She thanked all who were there.

The word *ajn* is often used after the tabulated words. It resembles "ever," which is found in the English words "whoever, whenever, wherever," etc., and is used in just the same way, except that it is not joined to the preceding word.

Example: *kiu ajn,* whoever; *kio ajn,* whatever.

When any of the nine words in column 3 are used at the beginning of a sentence to ask a question, the interrogative *ĉu* is not required.

Example: *Kie vi aĉetis tian ĉapelon?* Where did you buy that hat?

All the words in the tables are root words, and the nature of many of them (though not of all) permits the addition of the final *o, a,* or *e.*

Example: *Li ĉiame plendas,* He everlastingly complains; *mi ne scias la kialon,* I do not know the reason (the why); *La ĉiea ŝerculo,* the ubiquitous wag.

Vocabulary

Aĝ'. age
angul', corner, angle
aper', appear
atak', attack
aŭskult', listen
aŭtun', autumn
barakt', struggle
dat', date (time)
diven', guess
fal', fall
flug', fly (v. i.)
gajn', gain, win
ĝen', trouble, disturb
halt', come to a stop
insist', earnest insistent
just', just, righteous
koleg', colleague
konduk, conduct, lead
kondut', conduct, behaviour
konven', suitable fitting
kost', cost, price
kulp', fault, blame
kutim', custom
kvant', quantity
larm' tear (subst.)
laŭd', praise
mank', lack, want
memor', memory
mizer', misery, distress
moder', moderate
mol', soft
monat', month
montr', show (v. t.)
mord', bite
naci', nation
naz', nose
nobl', noble
obstin', obstinate
printemp', spring (season)
progres', progress
profund', deep
promes', promise
publik', public
rapid', rapid, fast
subit', sudden, instantaneous
sufiĉ', sufficient
sukces', success
ten' hold
tir', draw, pull

EXERCISE X.

When you saw him with such a strange person, why did you not speak to me? Which are the four seasons of the year? Spring, summer, autumn, winter. These men, whose conduct I disapproved, suddenly attacked me, five at a time. What (how much) is today's date? Can you guess my age? Where did you throw it? The stone fell there. That is certainly just. I never at any time met your colleagues of whom you speak. How much does this old book cost? Tears fell from her eyes one by one when she heard the reason. I can never pardon (to) them their faults, but when their conduct gains my approval then I will praise them. My memory always to some extent deceives me. The dog that barks loudly never bites. All nations progress, some rapidly, others slowly. The water here is rather deep. That is sufficient. We must work to earn that which it is necessary to have —that is, money. I nowhere and never said such words. I have as many cares as you. Why did you not listen to him? When he heard

my voice he stopped, and then for some reason suddenly ran into the house. I want to know what (that which) he said to you about such public matters. Here is somebody's glove. Whose is it ?

Key to Exercise IX.

Unu jaro havas dek du monatojn ; Julio estas la sepa. Ĝi havas tridek unu tagojn, kaj sekvas Junion. La ceteraj monatoj estas Januaro, Februaro, Marto, Aprilo, Majo, Aŭgusto, Septembro, Oktobro, Novembro, kaj fine griza kaj malluma Decembro. Gefiloj. Gefratoj. Genevoj. Geavoj. Geviroj. Gesinjoroj. Gefianĉoj. Li flatas sin, sed li ne konvinkis min. Ŝi ekridis. Mi ekpensas, ke vi volas trompi min. Mia nepo resendis la leteron al mi. Ŝi skribis sur pecon de papero. Mi serĉis la buteron, kaj fine ĝin trovis sub la ĵurnalo. Mi falis sur miajn genuojn, kaj ĵuris ke mi redonis la monon. Matene oni vidas la sunon en la oriento. Vespere ĝi estas en la okcidento. La kaĝo pendas sur la muro ekster la domo. Ŝi trankvile remetis la fluidon en la botelon. Miaj gekuzoj nutris la tiŝojn. La folio falis de la arbo al la tero. Li falis en la riveron. Ili akompanis min ĝis la teatro. Ili penis konsoli ŝin, sed ne povis. La plej bonaj el ni devos morti kaj reiri al la tero tra la tomboj. Terura vento ekblovis kaj la nuboj kaŝis la sunon.

Continued

GREEK

Continued from page 5376

By G. K. Hibbert, M.A.

SECTION I. ACCIDENCE

Adjectives: First and Second Declensions. The adjectival endings of the first and second declensions are usually *ος, η, ον* (masc., fem., neut.). The feminine is declined like a feminine noun of the first declension, and the masculine and neuter like nouns of the second declension. If a vowel or *ρ* precedes the termination *ος*, the feminine ends in *α*, not in *η*. Thus, *σοφός, σοφή, σοφόν* (wise) ; *ἐχθρός, ἐχθρά, ἐχθρόν* (hostile)

Singular

N.	σοφός	σοφή	σοφόν	ἐχθρός	ἐχθρά	ἐχθρόν
V.	σοφέ	σοφή	σοφόν	ἐχθρέ	ἐχθρά	ἐχθρόν
A.	σοφόν	σοφήν	σοφόν	ἐχθρόν	ἐχθράν	ἐχθρόν
G.	τοφοῦ	σοφῆς	σοφοῦ	ἐχθροῦ	ἐχθρᾶς	ἐχθροῦ
D	σοφῷ	σοφῇ	σοφῷ	ἐχθρῷ	ἐχθρᾷ	ἐχθρῷ

Dual

N. V. A.	σοφώ	σοφά	σοφώ	ἐχθρώ	ἐχθρά	ἐχθρώ
G. D.	σοφοῖν	σοφαῖν	σοφοῖν	ἐχθροῖν	ἐχθραῖν	ἐχθροῖν

Plural

N. V.	σοφοί	σοφαί	σοφά	ἐχθροί	ἐχθραί	ἐχθρά
A.	σοφούς	σοφάς	σοφά	ἐχθρούς	ἐχθράς	ἐχθρά
G.	σοφῶν	σοφῶν	σοφῶν	ἐχθρῶν	ἐχθρῶν	ἐχθρῶν
D.	σοφοῖς	σοφαῖς	σοφοῖς	ἐχθροῖς	ἐχθραῖς	ἐχθροῖς

Note. The masculine form of the dual is often used for the feminine, and forms like *σοφά* and *σοφαῖν* are rare.

Some adjectives in *ος*, however, have only two endings, *ος* and *ον*, the feminine ending in *ος* like the masculine—*e.g.*, *ἄδικος, ἄδικον*, unjust ; *ἄλογος, ἄλογον*, unreasonable.

Most adjectives ending in *εος* and *οος* are contracted, thus : *χρυσέος, χρυσέα, χρυσέον*, golden, becomes *χρυσοῦς, χρυσῆ, χρυσοῦν* ; *ἀργυρέος, ἀργυρέα, ἀργυρέον*, silver, becomes *ἀργυροῦς, ἀργυρᾶ, ἀργυροῦν* ; and *ἁπλόος, ἁπλόη, ἁπλόον*, simple, becomes *ἁπλοῦς, ἁπλῆ, ἁπλοῦν*, in the next column.

There are a few adjectives of the second declension ending in *ως* (masculine and feminine), *ων* (neuter), corresponding to the nouns of the Attic declension [see *νεώς*]. Thus *ἵλεως*, gracious, is declined in the next column.

Singular

	Masc.	*Fem.*	*Neuter*	*Masc., Fem.*	*Neuter*
N.	ἁπλοῦς	ἁπλῆ	ἁπλοῦν	ἵλεως	ἵλεων
A.	ἁπλοῦν	ἁπλῆν	ἁπλοῦν	ἵλεων	ἵλεων
G.	ἁπλοῦ	ἁπλῆς	ἁπλοῦ	ἵλεω	ἵλεω
D.	ἁπλῷ	ἁπλῇ	ἁπλῷ	ἵλεῳ	ἵλεῳ

Dual

N., V., A.	ἁπλώ	ἁπλά	ἁπλώ	ἵλεω	ἱλεω
G., D.	ἁπλοῖν	ἁπλαῖν	ἁπλοῖν	ἵλεῳν	ἱλεῳν

Plural

N.	ἁπλοῖ	ἁπλαῖ	ἁπλᾶ	ἱλεῳ	ἱλεω
A.	ἁπλοῦς	ἁπλᾶς	ἁπλᾶ	ἱλεως	ἱλεω
G.	ἁπλῶν	ἁπλῶν	ἁπλῶν	ἱλεων	ἱλεων
D.	ἁπλοῖς	ἁπλαῖς	ἁπλοῖς	ἵλεῳς	ἱλεῳς

Exercise III.

Turn the following into Greek, remembering that adjective and article must agree with the noun in number, gender, and case :

1. Of the simple girl. 2. To the hostile soldier. 3. Golden gifts. 4. Of the wise young men. 5. The unjust girl (accusative). 6. To the silver sea. 7. Unreasonable laws. 8. Of the wise mind. 9. Of the golden temple. 10. The simple judges (accusative).

Third Declension Nouns: The stems usually ending in a consonant.

The third declension includes all nouns not belonging to one or other of the two previous declensions. The stem of a noun of the third declension is generally found by dropping the termination of the genitive singular *ος* or *ως* : thus, *λέων, λέοντος*, stem *λέοντ–*.

The cases are formed by adding the following endings to the stem :

	Singular		*Dual*	*Plural*	
	Masc. & Fem.,	*Ntr.*	*Masc., Fm., Ntr.*	*Masc. & Fem,*	*Ntr.*
N.	ς	none	ε	ες	α
A.	α or ν	none	ε	ας	α
G.	ος, ως		οιν	ων	
D.	ι		οιν	σι	

NOTE. In the nominative singular and dative plural the terminations ς and σι respectively often become united with the last letter of the stem, as φύλαξ, guard, for φυλακ-ς; and dative plural φύλαξι, for φυλακ-σι.

The following are examples of the commonest forms of nouns of this declension with mute or liquid stems:

MASCULINES and FEMININES

ὁ κόραξ, raven; ἡ μάστιξ, whip; ὁ λέων, lion.

	Singular		
Nom.	κόραξ	μάστιξ	λέων
Voc.	κόραξ	μάστιξ	λέον
Acc.	κόρακα	μάστιγα	λέοντα
Gen.	κόρακος	μάστιγος	λέοντος
Dat.	κόρακι	μάστιγι	λέοντι
	Dual		
N., V., A.	κόρακε	μάστιγε	λέοντε
Gen., Dat.	κοράκοιν	μαστίγοιν	λεόντοιν
	Plural		
Nom., Voc.	κόρακες	μάστιγες	λέοντες
Acc.	κόρακας	μάστιγας	λέοντας
Gen.	κοράκων	μαστίγων	λεόντων
Dat.	κόραξι	μάστιξι	λέουσι

ὁ παῖς, boy; ὁ or ἡ ὄρνις, bird; ὁ γίγας, giant.

	Singular		
Nom.	παῖς	ὄρνις	γίγας
Voc.	παῖ	ὄρνι	γίγαν
Acc.	παῖδα	ὄρνιν or ὄρνιθα	γίγαντα
Gen.	παιδός	ὄρνιθος	γίγαντος
Dat.	παιδί	ὄρνιθι	γίγαντι
	Dual		
N., V., A.	παῖδε	ὄρνιθε	γίγαντε
Gen., Dat.	παιδοῖν	ὀρνίθοιν	γιγάντοιν
	Plural		
Nom., Voc.	παῖδες	ὄρνιθες	γίγαντες
Acc.	παῖδας	ὄρνιθας	γίγαντας
Gen.	παίδων	ὀρνίθων	γιγάντων
Dat.	παισί	ὄρνισι	γίγασι

In the same way decline the following nouns of this declension:

	Gen. sing.	*Dat. pl.*
ἡ φλέψ, vein	φλεβός	φλεψί
ὁ γύψ, vulture	γυπός	γυψί
ὁ φύλαξ, guard	φύλακος	φύλαξι
ὁ κῆρυξ, herald	κήρυκος	κήρυξι
ἡ πτέρυξ, wing	πτέρυγος	πτέρυξι
ἡ σάλπιγξ, trumpet (pronounced *salpinx*)	σάλπιγγος	σάλπιγξι
ὁ ὄνυξ, nail, claw	ὄνυχος	ὄνυξι
ὁ ἄναξ, chief, prince (poetical voc. ἄνα)	ἄνακτος	ἄναξι
ἡ νύξ, night	νυκτός	νυξί
ὁ γέλως, laughter	γέλωτος	—
ἡ Ἑλλάς, Greece	Ἑλλάδος	—
ἡ κόρυς, helmet	κόρυθος	κόρυσι
ἡ ἐλπίς, hope (voc. ἐλπί)	ἐλπίδος	ἐλπίσι
ἡ λαμπάς, torch	λαμπάδος	λαμπάσι
ἡ πατρίς, native land	πατρίδος	πατρίσι
ὁ ἐλέφας, elephant	ἐλέφαντος	ἐλέφασι
ὁ γέρων, old man (voc. γέρον)	γέροντος	γέρουσι
ὁ ὀδούς, tooth	ὀδόντος	ὀδοῦσι
ὁ ποιμήν, shepherd	ποιμένος	ποιμέσι
ὁ λιμήν, harbour	λιμένος	λιμέσι
ὁ Ἕλλην, Greek	Ἕλληνος	Ἕλλησι
ὁ μήν, month	μηνός	μησί
ὁ αἰών, age	αἰῶνος	αἰῶσι
ὁ χειμών, winter, storm	χειμῶνος	χειμῶσι
ὁ ἡγεμών, leader	ἡγεμόνος	ἡγεμόσι
ἡ χιών, snow	χιόνος	—
ὁ δαίμων, divinity (voc. δαῖμον)	δαίμονος	δαίμοσι
ὁ δελφίς, dolphin	δελφῖνος	δελφῖσι
ὁ ἅλς, salt	ἁλός	ἁλσί
ὁ θήρ, wild beast	θηρός	θηρσί
ὁ θής, hired man	θητός	θησί
ἡ ῥίς, nose (cf. "*rhinoceros*")	ῥινός	ῥισί
ὁ ῥήτωρ, orator (voc. ῥῆτορ)	ῥήτορος	ῥήτορσι

NEUTERS

τὸ σῶμα, body; τὸ πέρας, end; τὸ ἧπαρ, liver.

	Singular		
N., V., A.	σῶμα	πέρας	ἧπαρ
Gen.	σώματος	πέρατος	ἥπατος
Dat.	σώματι	πέρατι	ἥπατι
	Dual		
N., V., A.	σώματε	πέρατε	ἥπατε
Gen., Dat.	σωμάτοιν	περάτοιν	ἡπάτοιν
	Plural		
N., V., A.	σώματα	πέρατα	ἥπατα
Gen.	σωμάτων	περάτων	ἡπάτων
Dat.	σώμασι	πέρασι	ἥπασι

Like σῶμα decline τὸ πρᾶγμα, thing, affair; (τὰ πράγματα = business).

Third Declension Adjectives. Adjectives of the third declension have usually two endings, one for masculine and feminine, the other for neuter. Most of these end in ης (neuter ες) and ων (neuter ον), as ἀληθής, true; ψευδής, false; πλήρης, full; εὐδαίμων, happy; πέπων, ripe; σώφρων, prudent. They are thus declined:

	Masc. & Fem.	*Neuter.*		*Masc. & Fem.*	*Neuter.*
	Singular			*Singular*	
N.	ἀληθής	ἀληθές	*N.*	εὐδαίμων	εὔδαιμον
V.	ἀληθές		*V.*	εὔδαιμον	
A.	ἀληθῆ	ἀληθές	*A.*	εὐδαίμονα	εὔδαιμον
G.	ἀληθοῦς (for ἀληθέος)		*G.*	εὐδαίμονος	
D.	ἀληθεῖ (for ἀληθέϊ)		*D.*	εὐδαίμονι	
	Dual			*Dual*	
N., V., A.	ἀληθῆ		*N., V., A.*	εὐδαίμονε	
G., D.	ἀληθοῖν		*G., D.*	εὐδαιμόνοιν	
	Plural			*Plural*	
N. V.	ἀληθεῖς (έες)	ἀληθῆ (έα)	*N. V.*	εὐδαίμονες	εὐδαίμονα
A.	ἀληθεῖς (έας)	ἀληθῆ	*A.*	εὐδαίμονας	εὐδαίμονα
G.	ἀληθῶν		*G.*	εὐδαιμόνων	
D.	ἀληθέσι		*D.*	εὐδαίμοσι	

Some adjectives of the third declension, however, have only one termination, as: πένης, genitive πένητος, poor; ἄπαις, ἄπαιδος, childless; ἀγνώς, ἀγνῶτος, unknown; ἅρπαξ, ἅρπαγος, rapacious; φυγάς, φυγάδος, fugitive.

Verb "To Be": *εἰμί,* I am.

	Pres. Indicative	*Imperf. Indicative*
1. *Singular*	εἰμί, I am	ἦν or ἦ, I was
2. ,,	εἶ, thou art	ἦσθα
3. ,,	ἐστί(ν), he is	ἦν
2. *Dual*	ἐστόν, you two are	ἦτον, you two were
3. ,,	ἐστόν, they ,, ,,	ἤτην
1. *Plural*	ἐσμέν, we are	ἦμεν, we were
2. ,,	ἐστέ, ye are	ἦτε
3. ,,	εἰσί(ν), they are	ἦσαν

NOTES. 1. The first person dual of verbs is the same as the first person plural; it is not often used, and is therefore generally omitted in learning the verbs.

2. In present or primary tenses the second and third persons of the dual are alike, each ending in *ον*; but in past or historic tenses the third dual ends in *ην* (cf. *ἤτην* above).

3. When *ἐστί* and *εἰσί* are followed by a word beginning with a vowel, they are written *ἐστίν*, *εἰσίν*, for the sake of euphony or sound. The same applies to most words ending in *σι* (*e.g.*, all dative plurals of the third declension), and to all verbs of the third person singular ending in *ε*. Example: *οἱ ἵπποι χρήσιμοί εἰσιν ἐν τῷ πολέμῳ,* Horses are useful in war. This also holds good when any one of these words (*e.g.*, *ἐστί, εἰσί, πένησι*) is the last word in a sentence.

Regular Verb. *λύω,* I loose: Present and Future Indicative. The great majority of Greek verbs have the ending *ω* for the first person singular present indicative; the only other ending is *μι* (cf. *εἰμί*).

	Present	*Future*
1. *Singular*	λύω, I loose	λύσω, I shall loose
2. ,,	λύεις	λύσεις
3. ,,	λύει	λύσει
2. *Dual*	λύετον	λύσετον
3. ,,	λύετον	λύσετον
1. *Plural*	λύομεν	λύσομεν
2. ,,	λύετε	λύσετε
3. ,,	λύουσι(ν)	λύσουσι(ν)

SECTION II. SYNTAX

The ordinary rules of Syntax (such as the agreement of a verb with its subject in number and person, the agreement of an adjective with its noun in number, gender, and case) apply of course in Greek. These need not be recapitulated here.

RULE 1. When any part of *εἰμί,* am, connects the subject with a following noun or adjective the verb is called the *copula,* and the noun or adjective following is called the predicate. If in such sentences the predicate is a noun it will be in the same *case* as the subject; if it is an adjective, it will agree with the subject in *number, gender,* and *case*—*e.g.,* *Οἱ γέροντές εἰσι ῥήτορες,* The old men are orators; *Οἱ ἡγεμόνες ἦσαν σώφρονες,* The leaders were prudent.

RULE 2. In Greek a nominative in the *neuter plural* takes a *singular* verb—as, *Τὰ δῶρά ἐστι χρήσιμα,* The gifts are useful; *Τὰ ἄστρα ἦν φίλια,* The stars were friendly. (The Greeks regarded neuter plurals as forming a class, and as practically equalling a collective noun; hence the singular verb.)

RULE 3. Several subjects connected by *and* (*καί*) usually take a plural verb, and if the subjects are of different persons, the verb is in the first person rather than the second, and in the second rather than the third—as, *Ἐχθροὶ ἐγὼ καὶ σὺ ἐσμέν* = I and you are enemies (literally: "Hostile I and you, we are," the emphatic word coming first).

RULE 4. An adjective, with the article prefixed, is often used as a noun, the person or thing being understood—as, *ὁ σοφός* = the wise man; *οἱ δίκαιοι* = the just; *ἡ σοφή* = the wise woman; *τὰ ἄδικα* = unjust things, what is unjust (and so very often = injustice).

RULE 5. (Very important.) The article is not used with the predicate, only with the subject—as, *Ὄρνις ἦν τοῦ γέροντος δῶρον* = The bird was the gift of the old man (not *τὸ δῶρον*). In this way it is easy to distinguish the subject from the predicate, whatever the order of the words in the sentence. For example: *Διδάσκαλος τῆς κόρης ἦν ὁ ποιμήν* = The shepherd was the teacher of the girl. This rule will be found not to hold good in New Testament Greek, which is slightly different from Classical Greek.

EXERCISE IV.

[Words not found here have been given before]

and, *καί*	I hope for, *ἐλπίζω* (takes accusative)
in, *ἐν* (governing dative)	I say, *λέγω*
basket, *τὸ κανοῦν*	time, *ὁ χρόνος*
egg, *τὸ ᾠόν*	long, *μακρός, ά, όν*
I admire, *θαυμάζω*	but, *ἀλλά*
soon, *ταχέως*	unkind, *ἄγριος, α, ον*
wicked, *κακός, ή, όν*	I pursue, *διώκω*
I dance, *χορεύω*	I fall, *πίπτω*
delight, *ἡ χαρά*	ancient, *παλαιός*
not, *οὐ* (*οὐκ* when next word begins with a vowel unaspirated; *οὐχ* when next word begins with an aspirated vowel—*i.e.,* a rough breathing)	pleasant, *τερπνός, ή, ον*
	I run, *τρέχω*
	out of, from, *ἐκ* (governs genitive)
	sad, *οἰκτρος, ά, όν*
	Deity, *ὁ δαίμων*

that, *ὅτι* (conjunction)

Put into Greek: 1. There are a boy and a girl in the house (say, a boy and a girl are in the house). 2. The house is full of baskets, and in the baskets are eggs. 3. The eggs were the gift of the kind old man. 4. The boy admires the baskets: he loosens his (say *the*) outer garment. 5. He will soon loosen a basket. 6. The girl is wicked, and dances *with delight* (simple dative without a preposition). 7. She hopes for the eggs: she says "The time is long." 8. But the deity is unkind: he pursues the boy and the girl. 9. The basket falls: the eggs are ancient, and the house is not pleasant. 10. The boy and the girl run out of the house, sad and wise.

KEY TO EXERCISE I.: Rhododendron, diagnosis, agkura [pronounced *ancura* (*Latin* ancora, anchor)], metamorphosis, catastrophe, pantomimos, Xerxes, Socrates, psalterion (psalter).

KEY TO EXERCISE II.: 1. *τοῦ νεανίου.* 2. *τοῖς ὀστοῖς.* 3. *τὸν ναύτην.* 4. *τοῖν στρατιώταιν.* 5. *τοῦ νόμου.* 6. *τῷ ζώῳ.* 7. *οἱ ποταμοί.* 8. *τοῖς πολίταις.* 9. *τοῦ νεώ.* 10. *τὸ σῦκον.* 11. *τῆς νήσου.* 12. *αἱ κόραι.*

The next instalment of the ITALIAN Course appears in Part 39 of the SELF-EDUCATOR.

Continued

Portion of English wrought-iron screen of 1695 at Hampton Court Palace

Bronze gates, by Antonio Gai, in front of the loggia of the Campanile, Venice *Photo, Alinari*

FAMOUS EXAMPLES OF ART METAL WORK

[See METALS]

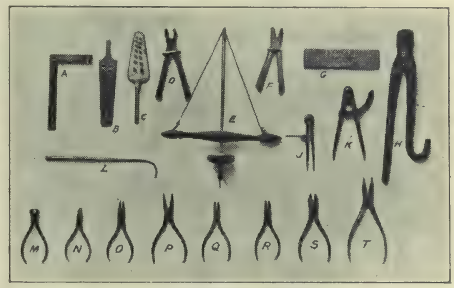
ART WORK IN METAL

Considerations of Art in the Treatment of Metals. Varieties of Metals. Embossing and Chasing. Casting, Spinning, and Turning. Engraving

Continued from page 5478

By ALEXANDER FISHER

THE work of the hand is the first and last consideration in the expression of art in metal-work of any kind. When such is adequately given, the result is always sufficient to justify its existence. There is no art in any piece of work which does not possess the qualities obtained by hand work. To demonstrate this it is only necessary to try to think of a machine producing a work of art. Such a thing is inconceivable, inasmuch as all art is the expression of man's thoughts and feelings. The hand well trained alone can achieve that. One of the most lamentable things is to witness the painful effort of a worker to imitate the result obtained by the use of machinery. In the ordinary workshop this seems to be the great desideratum—the *sine qua non*. That it is necessary, then, to make art objects with the hands implies also that the design must be such as can best be expressed by hand work. Hence it follows that all designs should be made by one who not only knows the methods employed in the craft, but has also either practised it or is working in it. Not only so, but he must also have the keenest sympathy and enthusiasm for it. The designer and craftsman should be one and the same person, until he knows the craft so thoroughly that he can guide the work while being made by other hands than his own. For it is the artist who, by working continually in a chosen material, best understands its capabilities and what beauties can be wrested from it, as well as its limitations and suitable application. It is this true appreciation of the qualities of a particular metal which calls forth the highest design. To make the point clearer, attention is called to the frequent misapplication of metal-work, shown by the reproductions of woodwork, stone carving and plaster moulding, in wrought metal. This proceeds from a mistaken view of the use of metals, or the lack of either the knowledge of its capabilities or of invention and sympathy on the part of the designer. Not only is this true of the material, but also of the process, as in the case of wrought and cast work, where the difference should be felt and understood throughout the whole design.



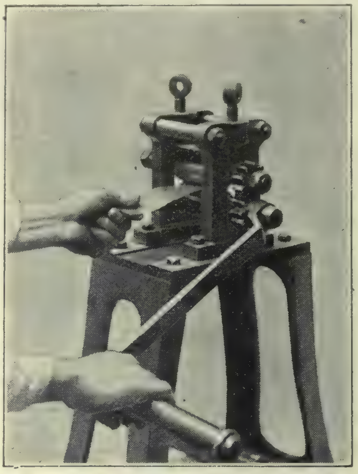
1. VARIOUS TOOLS
A. Steel straightedge *B* and *C*. Screw-plates *D* and *F*. Slide pliers *E*. Drill and stock *G*. Draw-plate *H*. Draw-tongs *J*. Spring dividers *K*. Wing compasses *L*. Mouth blowpipe *M*. Nippers *N* to *T*. Varieties of pliers

Study and Practice. The study and practice of the craft should be carried on at the same time as the study of design, either upon paper or in wax. They should not be pursued separately—that is, at different periods, one taken up for several years, and then the other—lest they both suffer. For by realising and embodying the idea or conception in metal, the mind gradually becomes accustomed to seeing clearly the design being made from start to finish in all its parts. In fact, so clearly is it perceived, that after a time the conception will present itself as vividly before the mind's eye as though it existed in actual metal before it. It is one of the most difficult mental problems to design or draw anything without having a clear presentiment or vision of the object. The usual method is to grope about over a piece of paper until something suggests itself from the number of lines sketched in, which, when it comes to be made, is found to look quite different from the drawing. Therefore it is best to advocate as a system of training the development of a constructive imagination, by the continual practice of both the design and the craft. They should never be regarded in the light of separate things. It is this unnatural divorce between craft and design which has been one of the chief causes of most of the deplorable work of the beginning and middle of the last century and much of the work of to-day. And one can only look forward to the time when they shall be united once more. Another deterrent in the production of art of a lofty aim is the lack of interest in fine art work of to-day displayed by the purchasing public. We are told that attention and devotion to ancient art is caused by the absence of really fine work to-day. At least, then, let us remove this cause.

Simplest Art is the Highest Art. Now, for reference only, the best study is to be found amongst the old work of the early periods of any civilisation. For specimens of goldsmithing and jewellery, those amongst the ancient Irish, Celtic Greek, and what is left of Egyptian, Coptic and Scandinavian collections are to be sought; for wrought iron, British, German, Flemish, and French; for pewter, Dutch, English, and German; for silver, English, French, German, and Dutch; for enamels, French, German, and Italian. The earlier the date—in any civilisation of any piece of art work—the more generally does it imply the possession of those qualities which go to produce the finest art, such as simplicity, directness, purity of *motif*, restraint, virile strength, imagination and severity, together with the utmost perfection of handling and colour as seen in its best in the Irish jewellery. The later the period the more significant of redundance, femininity, extravagance, pretentiousness, poverty, and often impurity of *motif*—of conception, lack of breadth, simplicity, and the qualities possessed in earlier periods; such art work, so-called, has nothing but complete banality in all

its parts, as seen at its worst in the French and Flemish Rococo, and periods under the influence of the Jesuit Bourbons. The decadent periods are usually the precursors of social and artistic revolution. followed by a reaction affecting severity and simplicity, as seen in the Empire style of France and the Adams style in England.

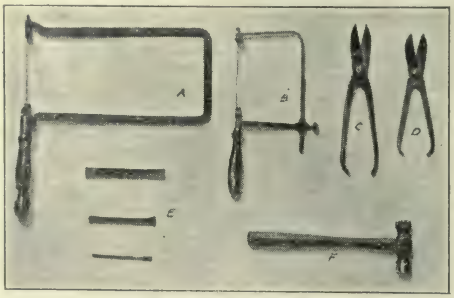
The True Value of Early Examples. The study of these styles or of any other should be for the sole purpose of understanding from them the expression of given forms and contours, contrasts and arrangements of line and mass. Not merely for the sake of the continuation and repetition of these styles, for no artist should be content to repeat the forms of expression used by men who have had their day and ceased to be. That is the wrong application of such study, and it is a sign of the times of how little is understood by the world of art when it is quite happy in seeing an endless purview of dead styles, thus causing on the part of artists and designers all effort of a sincere and original kind to be regarded as bad. This is prejudice and indifference, that kills or must be killed.



2. ROLLING METAL IN HAND MILL

This is a grotesque inversion of the idea held with regard to science and literature, and of what is considered advantageous and progressive for them. For in science the reverse holds good. In literature it would be considered unworthy for authors to imitate the idioms, phraseology and words, as much as repeating the ideas of writers in past times.

Study of Nature. Then, while studying ancient art, give more thought and reflection to Nature. Study her in all her varying moods, in her infinitely beautiful means of expression, from the smallest herb and flowering plant to the great trees, the movement expressed in their great limbs under the strain and stress of the storm, and the movement of the waters of the sea, and again the cloud masses. Then consider the lines expressive of calmness and strength in the steadfast hills; but study her most closely, intimately, in the forms and movements of animal life, and of the human figure. Do not study with the intention of copying, so much as to analyse what feeling or intention can be best expressed by adopting similar lines, masses, contours, whether of strength, beauty, grace, grandeur, gentleness; ascertain how she builds her forms and clothes them.

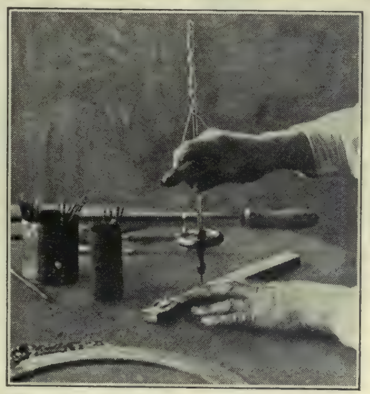


3. CUTTING TOOLS
A. Large frame and fret-saw *B.* Smaller ditto
C and *D.* Shears *E.* Chisels *F.* Hammer

Design. Referring in the most general terms to the broadest principles of design, it is necessary to bear in mind only that the straight line is the most beautiful of all lines, and that any deviation from it is less beautiful. Thus the curve, which is nearest the straight line, is the one that appeals to us most, as in early Egyptian, Greek, Celtic, and Saracenic art. So also in relief, flat surfaces are preferable to rounded, just as in the highest Greek form it is the flat planes and surfaces with the least curvature of parts which attain to that perfection of strength, beauty, and virility which one sees embodied there. Now, one of the great qualities in design is that described as "largeness of feeling." By analysis of most of those works which are generally conceded to be the finest, it will be noticed that this quality is maintained by simplicity, directness and singleness of conception, and scale in execution. It will be observed that there is a total absence of short curves, of violent light and shade, of prominent detail, and of confusion of parts, multiplicity of ideas, or complexity of aim. Detail, enrichment of surface, or ornament, elaboration of plan, were used so as to emphasise the beauty of the bare spaces, and in so doing these gave great preciousness to the enrichment. For it is apparent that straight lines, flat planes, simplicity of plan stand for and represent the great abstract quality *repose*, and therefore continuity, which implies infinity. In a similar way a curved line or surface repeated a great number of times suggests the same quality in a minor degree. If follows that all masses or curves, such as waves of the sea, or elaborations of whatever kind, carried on in a straight direction, repeated over a surface, represent the same idea. The trunk of a fir-tree, as straight as a column, or the slight curving growth of a chestnut, both indicate repose, because of the straightness of the direction of their growth. Contrast this with the gnarled oak. How eloquent it is of storms encountered and fought with! So that the broad principle is that continuity and simplicity, as represented by flatness of surface or straightness of direction, signify repose, infinity, and in the greatest work the sublime; and the contorted, twisted, intersecting, are emblematic of change. The smaller the curve and the more abrupt the angle of contour, the more rapid movement do they imply, and so on, in a descending scale.

Applying the Principles of Design. These general outlines the student must try to fill in for himself, and in doing so he will doubtless encounter many obstacles. But he will find ultimately that they are true. He will meet many things in nature, apart from the disputations of his fellows, which seem to say otherwise. It is important that

the student should understand the means of conveying his intention. If he wish to attempt to walk along the high and lonely road towards the lofty planes of the beautiful, he will find it necessary to exercise great restraint even while exercising his imagination to the full. He will find that the beautiful implies the abiding sense of continuity. Life itself is transitory in the individual, but continuous in the race. Reflect upon this, for it is generally understood that variety, change, and contrast are the most beautiful qualities in art, whereas the contrary is proved to be the case in all the greatest monuments of antiquity and the present day. Then, if in the greatest, surely in the humblest work also. To take but two of the best known examples of different styles, the Parthenon and the interior of Westminster Abbey. In the former the whole composition is made up of straight lines and flat planes. The interior at Westminster is similar in this respect where the shafts are simply a mass of upright columns tied together, which in their sustained length, gently and slowly curving at the top into arches, give the almost extreme perfection of the expression of aspiration in repose.



4. DRILLING WITH A DRILL IN A STOCK

Harmony in Art Work. Yet it is also one of the axioms of design that suitability of purpose should govern a building, and consequently the governing facts in its decoration should be that it is in harmony with that purpose. So that edifices of a serious great motive and intention shall be decorated only with suitable appropriate ornaments, just as much as those of a lighter character. These remarks seem to be so obviously true, and therefore unnecessary, yet how often does one see our theatres dull and heavy, our drawing-rooms uninspiring, our churches full of unsuitable crudities displaying the utmost poverty of imagination and inappropriateness of form and colour. All there is consists of only such ornaments as can be stolen from some historical document concerning the art of a period and religion of a character totally different from the present one; in fact, everything save that which should be in such places of worship, praise and prayer. The subject of design as applied to the right use of curves, accent, harmony, and other qualities, and the appropriate treatment of materials, are discussed in the article on Design.

5. SOLDERING WITH BLOWPIPE AND FOOT BELLOWS

Metals. The number of known metals is considerable, there being forty-five in all. The majority of these are suitable in one form or another for art metal work, although very few are employed to any great extent.

The following comparisons show the different properties and characters of metals, which are here arranged in the order of their suitability to the purpose named above them.

MALLEABILITY. Gold, silver, copper, tin, lead, brass, zinc, platinum, iron, aluminium.

DUCTILITY. Platinum, silver, iron, copper, gold, brass, aluminium, zinc, tin, lead.

FUSIBILITY. Aluminium, tin, lead, zinc, brass, bronze, silver, copper, gold, iron, platinum.

ALLOYS. Copper alloyed with zinc gives brass, copper alloyed with tin gives bronze, silver alloyed with copper gives standard silver, gold alloyed with silver and copper gives the different carats of gold.

The junction of metals is attained by various means as follows:

In gold work the parts are joined by solder made of gold and silver or gold, silver, and copper melted together in proportions according to the carat of the gold.

In silver work a solder is also used made of silver and copper.

In copper work spelter made of copper and zinc, and a solder of copper and silver in much the same proportion.

In brass work spelter and a common silver solder, made of brass and silver is used.

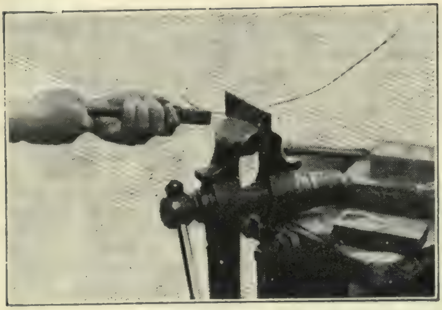
In iron work by welding and brazing.

In pewter, lead and tin and aluminium by fusion, and by pewter solder.

Nickel by silver solder.

All metals can be screwed, tied or riveted together.

That metals differ very widely in many respects, and that they are hard and soft and of different colour, is common knowledge. These differences can be modified considerably in most cases, which enables the worker to produce many things which otherwise would be impossible. Steel is the hardest metal. It is made from iron by introducing carbon into it while in a molten condition. But it can be made into a soft, pliable, or rigid metal according to the different properties of carbon and iron, or as brittle as glass by different applications of heat and methods of cooling afterwards. Possessing this remarkable quality it has become the most useful of all metals. Copper is the next most useful metal. Tin, lead, and zinc are largely used when mixed with other metals or applied to them. Gold and silver, besides being the most beautiful, are among the rarest metals found in the earth, and this prohibits them from being more generally employed. Other metals such as cadmium, vanadium,



6. DRAWING WIRE

palladium, nickel, mercury are untarnishable metals of a silvery quality, which are usually applied to other metals for their reflective qualities, and for the protection of others the surfaces of which would otherwise rapidly deteriorate through chemical change caused by the atmosphere.

Processes in Metal-work. In the manipulation of all metals, the same processes are employed. The main difference in treatment lies in the size of work and the quality of handling. In the precious metals, gold, silver, and platinum, the handling should be kept fine and delicate according to the size and preciousness of the material—consequently the tools [**1**] are small and minute, whereas in making wrought iron they are, comparatively speaking, of enormous size. The hammers and punches, the drills and stocks, the stakes, mandrels and files are naturally regulated by the size of the work. So that here we shall describe the processes in detail common to all, in reading which it will be necessary for the student only to think of his material—either copper, iron, steel, gold or silver—to understand the matter rightly. All metals can now be procured in the sheet, bar, rod, or wire of almost any dimensions. Most of these are prepared by machinery to-day, and are as perfect as is necessary for all intents and purposes. The method employed in making sheet metals is as follows:

An ingot of the metal is cast measuring and weighing the proportionate amount to the sheet required. This is hammered into a flat piece, and after annealing it is placed between the steel rollers of the rolling or flatting mills [**2**], and then rolled, the size being gradually reduced by the tightening of the rollers to the gauge decided upon.

The gauge is a flat piece of steel about $\frac{1}{8}$ in. thick, and having along both its edges a series of slots with a number marked below each for the purpose of quotations and reference, as seen in the illustration. There are two gauges in general use in this country, which causes great inconvenience owing to the frequent misunderstanding of the numbers quoted, so that it is highly necessary to state the kind of gauge which is referred to in an order. The names of these gauges are "Metal Gauge" and "Birmingham Wire Gauge."

7. "BLOCKING OUT" A BOWL

Sheet Metal. "Sheet" iron, copper, brass, gilding metal, are sold in sheets of varying dimensions, the most general size being about 4 ft. by 2 ft. The limit is according to the size of the rolling mills. To Mr. Sherard Cowper Coles we are indebted for an improvement in this limitation of size as regards copper inasmuch as by electrically depositing copper upon a cylinder a much greater size is reached and greater saving in the cost of production.

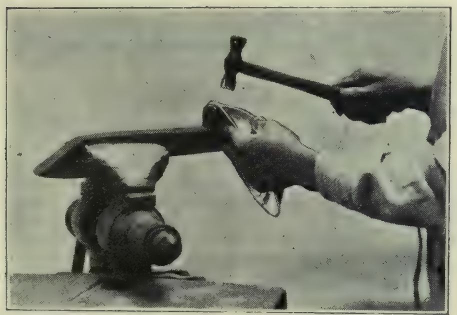
Annealing. Annealing is a word used to denote the process by which a metal is softened to its normal state after it becomes hard through bending, torsion, hammering, rolling, or through any process which involves the pressure of the particles of metal upon each other. Fine gold, fine silver, lead and tin do not become hard by hammering, but alloyed gold and silver, nevertheless, become hard enough to require annealing. Each metal requiring annealing is subject to the following treatment. It is first made hot, and kept hot equally all over, if possible, for a few minutes, and then allowed to cool gradually. In the case of steel it is necessary to arrange so that it cools very slowly, protecting it from the air while so doing. Other metals do not require so much care, but brass, low carat gold and standard silver should never be cooled rapidly by plunging into cold water, as may be done with copper.

Cutting. For all the soft metals—gold, silver, copper, tin, lead, nickel, iron and brass—if of an ordinary thickness a pair of steel shears or cutting pliers, or a metal-saw or fret-saw [**3**] is used for cutting. Shears can be bought either curved or straight, and suitable for cutting with the left hand or right. Metal-saws of almost any size can also be readily obtained. For cutting hard metals or thick metals, steel chisels are used. The angle at which these are sharpened is a very wide one, in order to keep the strength well down to its cutting edge, and they are tempered to a straw colour. Fret-sawing is done by first drilling holes in the various parts to be cut out, and then passing the saw through, fixing it firmly in the frame, and sawing in the usual manner, keeping the saw at right angles to the sheet of metal.

Tempering. Although tempering belongs particularly to one metal only, yet, as it has to do entirely with tools, we must describe it here. The first thing in making a steel tool is to soften the steel by heating it to a pale red and allowing it to cool very gradually, and then, when cold, to file it into the desired shape if a straight tool, such as a chisel, and if for a curved tool, by bending it while red hot. Then, to temper it, the steel is hardened by heating it again to a pale, red colour and plunging it into cold water. After this, one side is cleaned by emery cloth, and then a blowpipe flame is applied to within an inch or half an inch, as the case may be, until this part appears blue and the tip an orange colour. The moment this is reached the tool is plunged once more into cold water to arrest its further progress of softening. Now the tool is hard where it is straw colour, but not brittle, and tough where it is blue, yet not soft enough to bend while being struck. Swords are tempered in the same way.

Drilling. In order to fix some parts of metal work together it frequently happens that they cannot be brazed, soldered, or welded together. In such cases the parts are held together by rivets or screws. Before any of these operations can be performed the separate pieces must be drilled [**4**]. Now, drilling is done either by means of a drill rotated by a bow, or fixed in a stock, or by a chuck placed in a lathe. A complete set of drills can be obtained from any silver or copper warehouse. The whole operation of drilling is a very simple one, as it entails merely the fixing of the drill securely into the breastplate if a bow is used, or into the stock or chuck, and causing it to revolve rapidly upon a given point. Drilling is aided by the addition of a little oil placed at the point of the drill for soft metals, and of soapy water for steel.

Soldering and Brazing. Soldering and brazing are identical in their process, which is performed as follows: The two surfaces are cleaned thoroughly either by filing or scraping or rubbing with emery paper, and when these parts are thoroughly clean the pieces of the metal are bound together with wire or held in position by clamps, or are fixed in fireclay or upon other stouter pieces of metal, and then the parts to be soldered or brazed are painted with borax dissolved in water, and the

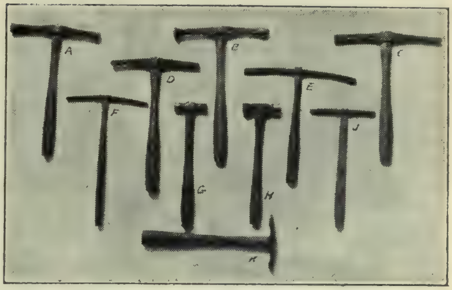


9. PLANISHING A SILVER BOWL ON A STEEL-FACED STAKE

solder is cut into small pieces, which are placed along the boraxed parts. When this has been done the whole is subjected to a red heat produced by a gas blowpipe [**5**]. In the case of small work, such as jewellery, a mouth blowpipe is preferable; but for large work a large blowpipe with a foot bellows is used.

Wire-drawing. The process of wire-drawing [**6**] is performed by means of pulling the wire through a regular series of holes pierced in a hard steel-plate by tongs. This plate is called a *draw-plate* and the tongs *draw-tongs.* As the metal wire becomes very hard and brittle in the process of drawing, it is necessary to anneal it repeatedly and to use a little oil when passing it through the plate.

Hammering. The methods employed are practically the same as have existed from antiquity. They consist of first raising the metal from the back and then finishing it from the front. The softer metals only are used for the purpose of making objects such as cups, tazzas, bowls, vases and other articles of a similar form. The tools employed are those of the most primitive yet effectual character. They are hammers of various kinds [**8**], as shown in the illustration, the size of which is naturally governed by the size of the object. The long-headed hammers are used for raising and drawing in the



8. HAMMERS FOR ART METAL WORKERS

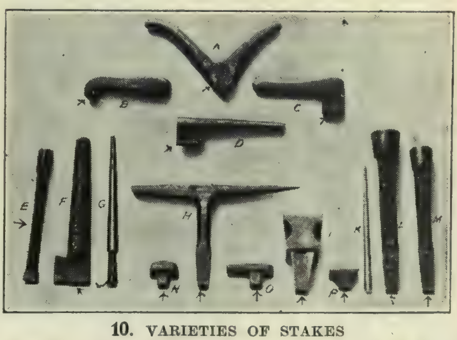
G and *H* are planishing hammers; the remainder are for raising, "blocking out" and "drawing in"

metal, and the short, flat ones for finishing and planishing, as it is called, with stakes, mandrels, angle wires, tee-pieces, etc.

The detailed process of raising and drawing of a silver bowl, such as the one in the illustration, is as follows:

Cut your piece of metal from a flat sheet No. 18 metal gauge. Measure the edge of the design from the centre of the base of the bowl to its edge, and allow a quarter of an inch for cutting and filing this true at the end of the operation. Then strike out on your silver a circle, with this as the radius, with a pair of steel dividers. When this is done cut it out with a pair of shears, and then place it upon a block of wood, similar to that used by a butcher; with a hammer made of buffalo horn strike it in a series of circles, with regular blows, holding the silver at an angle of about 25° to the block [**7**]. It is better if the block is slightly concave. Then anneal it. After it is cool, take the silver again, and by holding at an angle of 30°, repeat the process of hammering again; and so on, until it is raised into a shallow saucer. After it has been annealed and pickled, turn it over on to a stake of this shape, and strike it on the outside in a similar way [**9**], turning it slowly with the left hand as you hammer it.

The important thing to aim at is to direct each blow upon the part which is immediately in contact with the stake; each blow should produce a clear, sharp, metallic ring, and in this way the silver is stretched into the shape of the stake, which should, of course, be the shape of the cup at some part or another. From this it will be gathered that the



10. VARIETIES OF STAKES

A to *D*. Side stakes *E*. Canister stake *F*. Side stake *G*. Ring mandrel *H*. Beck iron *J*. Square-faced stake *K*. Ringed stake *L* and *M*. Canister stakes *N* to *P*. Heads for vice crank

stakes required [10] are considerable in number, as it is obvious that each section of a given bowl should have its corresponding stake upon which the metal can be beaten into shape. When each complete course of hammering has taken place, the silver must be annealed and carefully cleaned. Then the operation of planishing completes the process. It is exactly the same as other hammering, except that it is performed by a short, flat-headed hammer, with a polished face. From its lowest part up to the rim the cup is slowly and thoroughly beaten with it until all other hammer marks are erased, and a regular faceting of the surface has been given to it. If it is perfectly done it should not require to be polished afterwards.

The above description will apply equally to the raising of any forms in any metals. Such metals as nickel and steel are naturally unsuitable for this work, as they are too hard.

Embossing, Repousse, Chasing. *Embossing* and *chasing* are terms applied to the methods of enriching an object in metals by relief, produced through beating it with punches which are struck by a hammer first from the back to raise parts and then from the front to sink others, and to finish the raised parts.

The simplest form of embossing is done upon a lead block, and for large, simple decorative wrought work it is quite sufficient. But the finer kinds of "repoussé" or "embossed" work [11] are done upon a composition of pitch, plaster and oil. The great drawback to this composition is the amount of time taken up in fixing the plate to the pitch, and taking it off and re-cleaning it. But there is no other composition half so good. The tools are made from square steel rods, which are cut into lengths of 6 in. or 7 in. each, shaped at the ends according to the required line or relief. They are entirely dependent upon this and the size of the curves, or parts in relief for their shape. They are tempered straw colour at their ends. The number of tools of this kind that a chaser possesses is, as a rule, very great. As many as 150 are often required if the chaser does a great variety of work. Then he has small riffles, which are pieces of steel having at each end a little curved or flat tong of a file, either coarsely or finely grained. It is a method of work which is capable of giving great beauty and richness to metal surfaces.

11. METAL REPOUSSÉ SHRINE OF FOURTEENTH CENTURY WORKMANSHIP

After the design has been drawn or transferred to the back of a sheet of metal it is traced—that is, gone over with a flat blunt chisel-shaped tool, which is struck regularly with a chaser's hammer while the tool moves slowly along the line. The parts which are to be raised are forced up in the same manner with larger, rounder faced tools of the same convexity as that part of the relief. This is repeated, using different suitable tools until the whole presents from the other side a roughly-embossed relief. After it has been removed from the pitch and cleaned, the back now requires to be filled with pitch and placed upon a pitch block, or bowl, as the case may be. And the surface is improved by the gradual smoothing and finishing with punches. Here parts are made sharper and clearer, and there more soft and delicate. In 12 and 13 are illustrated some early specimens of art metal produced by these processes.

Casting. The central principle of casting, of which an example is shown in 15, consists in making a mould and then pouring metal into it, or depositing by electricity. There are three ways of doing this, properly speaking—by sand, by "lost wax" ("cire perdu" or "cera perduta") or by electrolytic deposition.

The first is carried out by making a piece mould in wet sand from a plaster of wax model, and then the parts are firmly placed together in an iron box. The whole sand mould is dried, and the metal, while in a liquid state, is poured into it.

The *cire perdu, cera perduta*, or lost wax method, differs widely from the above. It is briefly performed as follows: After a plaster mould has been taken of the original model in beeswax, with the least amount of rape oil added to soften it, together with a little colouring matter, it is pressed into it, thus giving a model in pure wax. A core is inserted of brickdust and plaster, and on the outside a very solid mass of the same composition is put. Upon the model rods of wax are set on its prominent parts, passing up through the outer mould. After the whole mass has been subjected to a continuous regular heat for some time, during which the mould has been drying and the wax running out, the metal is poured into the main duct, from which it is carried through the other ducts on to the mould. By this means the whole thing is practically reproduced as in the original, as the metal now occupies the exact position of the wax, as though the wax had been transformed to metal. Further details of casting will be found in the section on Sculpture.

Electric deposition is simply the deposition of copper or silver or gold into a gutta-percha or vulcanite mould, which is immersed in a bath of solution of sulphate of copper.

Spinning and Turning. Two modern methods, which are closely allied in their processes, are spinning and turning. They are mechanical methods, and are to be decried for many reasons, the most important of which is given at the beginning of the introduction. Yet it is necessary and advantageous to know how to accomplish a piece of true spinning and turning—for this reason, that there are frequently parts of an object in metal which have to be exactly fitting and corresponding to other parts in their construction, so that they cannot be so well or quickly done by any other means. Examples of the method of making

12. CUPS AND GOBLETS OF THE SIXTEENTH AND SEVENTEENTH CENTURIES

various objects will be illustrated and described in detail.

Spinning is a method which achieves the same result upon a piece of sheet metal as is produced by hammering. The manner in which this is performed by hand without the aid of power is as follows. First a shape, in its simplest contour, resembling that of the bowl, cup, or other object, is turned in a hard wood, such as box, beechwood, or mahogany. Upon this the metal is securely fixed, with its centre placed exactly against the back-centre of the lathe. Then the "chuck," as the wood shape is termed, is revolved, carrying with it the metal disc, and while revolving, the end of the long steel burnisher is pressed with considerable force against the chuck, the handle forced underneath the armpit, and the middle of the tool supported on the slide rest, so that the whole weight of the body can be used. This is aided either by the lathe being placed as near to a wall as would allow a man to put his back against, or a leather strap fastened to the lathe, which goes round his back, thus enabling him to push with great force the burnisher upon the metal, and so press it down upon the wooden shape. When the first shape has been reached, the metal is annealed and the wood is taken a further stage. Then the metal is turned a little more into the shape desired. The metal is then again fixed against the wood, and the process repeated until the object is finished.

13. EARLY ICELANDIC CHALICE OF SILVER PARCEL-GILT

Turning in metal is similar to any other turning. Sharp-edged, chisel-shaped tools are employed, such as are shown in **14**, while the metal, solid, or hollow, or held securely upon a wooden shape, is revolved upon the chuck. These tools cut into the metal, giving the required form. All the tools mentioned are, with the exception of the lathe, of the simplest possible description. There are in large workshops innumerable varieties of most of these, but they are generally such as are for large work and thick metal. They are time-saving machines where a number of men are employed, but are too costly for small workshops. The lathe, however, is almost a necessity, for with it many things can be done with ease which otherwise would waste the time of the artist craftsman.

The most suitable metals for spinning are gold, copper, silver, brass, and pewter; and for turning, brass, silver, and copper.

Acids. The acids which are used in metal-work and enamelling are sulphuric, nitric, hydrochloric, muriatic, hydrofluoric. They are employed for different purposes.

Sulphuric acid, mixed with water in the proportion of 1 part of acid to 20 parts of water, is the most useful for cleaning copper, silver, and gold, both before and after soldering. It cleans the metal

in both cases, so that in the first place the solder runs smoothly, and afterwards it dissolves the borax. It is most advantageously used when heated to boiling point. The first operation in cleaning metal—that is, of leaving the metal in cold sulphuric acid and water—is called *pickling;* the second is generally referred to as *boiling out.*

Nitric acid, or *aqua fortis,* is used in the process called *dipping* copper or brass objects. That is, after a piece of copper or brass has been cleaned in *pickle,* otherwise sulphuric acid and water, it is held on a copper wire and dipped into a bath of aqua fortis, which is commercial nitric acid. For most dipping it is sufficient to use it below the pure state. Dipping is a term given to the process of sudden immersion and removal from the bath, by which a brilliant surface is given to the metal.

Hydrochloric, or aqueous sulphuric acid, is sometimes preferred by goldsmiths for cleaning gold and giving it a yellow colour, as it dissolves the alloy of copper. It is also occasionally used in cleaning copper, particularly when it is to be electro-gilded afterwards. The most general use to which it is put is in what is termed "soft soldering," that is, soldering with pewter solder. For this purpose the acid—or, as it is popularly called, *spirits of salt*—is killed by dropping particles of zinc into the acid, which is then put upon the parts to be soldered.

Aqua regia is a mixture of hydrochloric and nitric acid.

Muriatic acid is largely used in colouring gold articles.

Hydrofluoric acid attacks any kind of enamel or glass. It decomposes the silicates, which are the chief parts of glass. For the purpose of removing any portion of the surface of enamel, or for dissolving it entirely, this acid is the only one which can be employed. It is a very dangerous acid, and should be used with great care.

14. VARIOUS TOOLS
A to *E*. Tools for spinning *F* to *K*. Turning tools
L to *Q*. Screw-cutting tools *R*. Hack-saw

Polishing. If a surface of metal be rough through filing, the method of smoothing and polishing by hand is as follows. Take rough emery cloth and rub it all over until the file marks are removed; then use a finer emery cloth, in grades, until the finest is used. After this, take powdered pumice and oil, and with a stiff brush scrub it all over until a smooth surface is obtained. Then, with a soft woollen or worsted material and rottenstone mixed with oil, rub it again, when a dull polish will be given. Then, with a chamois leather and rouge polish it brightly. To polish in a lathe the same means are employed, save that mops, buffs, and laps are employed, fixed on the chuck.

Burnishing. By the use of a burnisher, either of steel, hematite, or agate, a still higher degree of polish can be obtained. Burnishers are made in all kinds of shapes to meet the requirements of the article to be burnished, and are used with a little soapy water. Continual light rubbing in various directions, while the object is held rigidly in a piece of fine tissue paper or chamois leather, produces a brilliant burnished surface.

Engraving. Properly speaking, this art is the oldest of all known methods of enriching metallic surfaces, as it is found in the earliest periods of the Bronze Age. For with a pointed instrument made of hard stone, such as a flint, it was found that a line could be scratched or cut in the metal. From this to the exquisitely engraved work of the Irish Celtic jewellery [**16**], and later of the fifteenth and sixteenth centuries, is, after all, a small step in result, yet it took ages in its achievement. The great obstacle in the development was the tardiness with which the discovery of steel was made. From the smelting of bronze to that of iron whole periods of the struggle for existence and for man's development passed away. Then, from the forging of iron to its conversion into steel, even in the most primitive form, necessitated long stretches of time in human advancement. The conquest of material and the subjugation of natural forces to man's will is a slow one, even when, as now, the greatest talent is devoted exclusively to that particular direction and aim. When the mind has been taught to rely upon itself for aid, and has been slowly but laboriously disencumbered of all the wild phantasmagoria inherent to the savage man-child, we come to the development when we can go out and obtain in the simplest fashion the steel graver of to-day.

Engraving Tools. Yet no discovery which simplifies things for the many is entirely without its drawbacks for the individual. The tools which, as in this case, are to be used directly by the hand must be such as will suit the hand of the operator using them. Therefore, when you have purchased them, the first thing you will find is that it is necessary to shorten the tools and cut the handle to the shape of your own particular hand. Many engravers find it advantageous to employ a long handle with a small, roundish head that will fit into the palm of the hand. Others prefer a short handle. Again, most of the tools, gravers, spitzsticklers, scorpers, etc., are cut at a too oblique angle for metal engraving—which causes the edge to be liable to break. The first thing to do, then, is to make the tool and handle fit your own hands. If you find it advantageous to shorten the tool, you must first of all soften the steel by heating it to a pale red, and then allow it to cool, after which you file it down, smooth it up with emery cloth, and then temper it as already described. Then sharpen upon an oilstone (fine Turkey stone is the best, and should always be kept clean and covered, to protect it from dust). In sharpening, take care not to cut the stone into grooves, or you will spoil it, and it will be of no further use.

The next thing to do is to fasten your plate, or cup, or whatever the object is, firmly upon a stick or block, as the case may be. For small work, such as a ring or pendant, place some melted resin on the end of a round stick, then warm the resin, and fasten the article to it. If, on the other hand, the object is a cup or large object, fill it with pitch and put it upon a pitch block as though for chasing. Then hold the arm rigidly, the thumb pressed firmly against the plate, and by pressing with the back of the hand forward and rotating the stick —or block—in a contrary direction as the design may require, the line will be cut. It is obvious that the tool must cut along laterally, and not in a

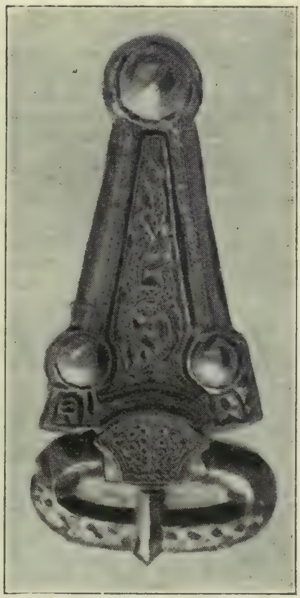
downward direction, and it is by constant practice that this is acquired. The line is then cut deeper and broader, according to the boldness or delicacy desired.

For different effects the line is cut hollow, curved, V-shaped, or flat; for each of these the tool must be accurately made. It is a good thing to practise cutting all sorts of curves by different gravers and comparing the result, and then examining the best work through the knowledge thus obtained. For damascening, niello, and enamelling the same process is employed, with this sole difference, that the parts in which the gold or silver is to be let in the steel, as in damascening—or the sulphide of silver and lead to be melted in as in niello, or the enamel fused in the spaces cut out as in champlevé enamelling—the parts are cut much deeper than is the case for engraving simply. These latter processes will be described under their proper headings.

15. FLEMISH CAST BRASS EWER OF FOURTEENTH CENTURY

Engraving, on a small scale, either for gold, silver, copper, brass or iron is invariably done by the unaided pressure of the hand holding the graver. But for large work, such as memorial brasses for inscriptions, hammer and chisels are used. In this case the chisel is held in the left hand and struck with a chaser's hammer, much in the same way that repoussé tools are used, save that instead of beating the chisel while holding it at right angles to the surface of the metal as in repoussé, the chisel is held obliquely at about an angle of 45°. Little pieces are flaked off at about every third blow. Another method is properly described as etching, but it is often erroneously referred to as engraving by acid, and does not come into this category.

Die=sinking. Die-sinking is very intimately connected with engraving and carving. Carving is very rarely done, as metal does not yield to such treatment as well as to other methods described. But die-sinking is one of the most common of the operations to which metals are subject, and it is at the same time a distinct method, so that it requires adequate description. It is generally used in striking medals, coins, badges, or other articles in bronze, copper, silver, or gold, in which fine detail is required, and where the work is to be reproduced many times. A block of steel is used. It measures across the face a little more than the piece to be struck, and deep according to the size of this face, in order to withstand enormous pressure. Then, upon this prepared surface — that is, a perfectly true smooth surface—a mould is carved with steel chisels, gravers and riffles. A very careful model is made in plaster, and is then copied in the steel. It is a work which requires the greatest knowledge of the use of tools, as well as the most careful concentrated effort. A really fine knowledge of form and modelling is absolutely necessary. While the process of carving or die-sinking is in progress, wax impressions must be repeatedly taken in order to see how the work is going on. When it is complete, the surface must be tempered, and upon this being satisfactorily accomplished, the die is placed in a press, or underneath a heavy bolt, raised by a pulley and dropped, and the metal disc is struck. If the die is not properly annealed and tempered it will crack in this process. The metal disc also must be of the softest description and carefully annealed.



16. SILVER-GILT FILIGREE BUCKLE

Niello. Niello is an inlay of an amalgam of silver, lead, and copper, in the proportion of 12 parts of silver, two parts of copper, and one of lead, to which is added powdered sulphur in excess, while the mixture is in a fluid state in the crucible. This is pulverised when cold, and into the engraved parts of silver, gold or copper the powder is placed. But before doing this it is necessary to apply a little borax, and run it well on to the engraved parts, then the powdered amalgam is shaken all over the metal thickly and baked. After it is withdrawn and the defective parts mended, the whole is rubbed down with files and emery, and finally polished. It was at one time very largely used upon silver. A considerable amount is still done in Italy and Spain, but it has never been very much in request in England, probably owing to its absence of colour. The great examples are the altar frontals at Pistoria Cathedral and at the baptistery at Florence.

Continued

NOW AND FOREVER

Man Must Live Not for Now Only, but for Ever. A Fair Field and No Favour for Truth. Factors that Mould Society. The End of the State is Liberty for All

By Dr. C. W. SALEEBY

NATURE'S rule has always been "a fair field and no favour." Let the strongest and the fleetest win; whatever can survive may survive. But there is to be no shrinking from the contest; "natural selection is the dread ordeal which must be passed by every aspirant to existence." It is a law at once benign and terrible. The conditions must be the same in the battle of ideas. We must have a fair field and no favour. "Established" ideas, whether they be those of established Churches or Royal Academies, or Royal Societies, or the House of Lords, must come out into the open. If they are right they will win; and if they are lies, is not an established lie the worst of lies?

No Quarter for a Lie. This transference of the plane of struggle has a definite interest for the moralist. Though natural selection acting on the physical plane is benign in the last resort, yet it is terrible. Nature has no mercy on the unfit, and they die of murder, cannibalism, or starvation. But when the battle is transferred to the plane of ideas, this terrible aspect of the defeat which is always implied in victory is found to vanish completely. Suffering now accrues only to those who will not bend the knee to the truth. As for the beaten and exposed idea, it is not a sentient thing, but an abstraction, and it cannot suffer. On the plane of the physical there is good cause for some mercy to the defeated, even though their defeat is a necessary condition of progress. But on the spiritual plane there is no need for mercy at all. It is a misplaced tenderness, then, that would deal gently with lies. Let them be gibbeted as such; it does not "hurt" them, and it is in our highest interests. Let the fight be fought without mercy and without quarter. Let our motto be "No quarter for lies." This is no place for mercy. Lightly to estimate a lie is lightly to estimate the truth which it belies. But in this great struggle to which we are all called we must distinguish between the idea and its personal champions.

Error is Not Sin. No better illustration of the principle which we are trying to express can be found than in the well-known saying that "God hates sin but loves the sinner." There is to be no quarter for lies, but we are not to confound the lie with him who mistook it for the truth. We are doubtless in the same case ourselves as to many of our beliefs. It is not immoral morally to hold an immoral doctrine. At one time, when first there began that great battle of ideas which is the great fact of our time, it was held that the holding of a false belief was the act of an evil will: "Error is sin." "Bishop Martensen once declared that the only explanation of the defection of men like Kant, Jacobi, Schiller and Goethe, from the doctrine of the Church was that in the depths of their hearts they entertained an antipathy towards the holiness of the Godhead." On the contrary, we must combine with our warcry, "No quarter for lies," a recognition of the imperfection of the human mind and the humility which knows that even a Newton is only a child picking up pebbles on the shore of the ocean of unplumbed and illimitable truth.

The Search for Truth. Says Herbert Spencer in his great discussion of the reconciliation between religion and science: "In proportion as we love truth more and victory less, we shall become anxious to know what it is which leads our opponents to think as they do. We shall begin to suspect that the pertinacity of belief exhibited by them must result from a perception of something we have not perceived. And we shall aim to supplement the portion of truth we have found with the portion found by them."

If the reader asks whether we are straying far from sociology let it be answered that, on the contrary, we are at the very heart of our subject, for we have been endeavouring to discuss, upon the basis provided by the solid ground of Nature, those great principles which underlie all the possibilities of social progress.

The reader remembers the great quotation from Wordsworth, of course:

> "To the solid ground
> Of Nature trusts the mind which builds for aye."

If we use the great names conservative and liberal in senses worthy of them, so that they are really capable of analogy with heredity and variation, we may distinguish in society certain forces or institutions or individuals who stand for perpetuation, and others who stand for innovation. In general terms, then, we find that the most vigorous and active years of life display the tendency to liberalism, or variation, whilst old-age displays a tendency to conservatism, or to the perpetuation of what is already established.

The Conservatism of Old Age. This conservatism of old age is, needless to say, an extremely valuable complement—the old man would say antidote—to liberalism, the openness of mind, the readiness to accept the new, which is more characteristic of youth. It is worth noting that the conservatism of old age, which in a man's second childhood is extremely marked, is a return of the marked conservatism of childhood itself. There is no more conservative society than that of a boys' school. It may also be noted that in primitive societies, corresponding to the childhood of the race, conservatism is the rule—the laws of custom being laws of iron. Whilst saying these things we

must not underrate the value of the reasonable conservatism of elderly men and women. These constitute by far the most valuable conservative forces of society, for they have had experience, which means that they have gone some way at any rate towards proving all things. On the other hand, government by grey-beards without its complement, the influence of youth, has always proved itself disastrous. In an ideal society, where all men are philosophers, youth and age will perfectly understand their respective tendencies and will perfectly understand that the best results follow, not when youth has its way, nor yet when age has its way, but when the tendencies of the two are combined.

The Conservatism of Women. Turning from individuals to the sexes, we must recognise that, on the whole, men constitute the liberal sex and women the conservative sex. Women prefer to make the best of existing circumstances and customs and to insist upon their good points, whilst, on the whole, the male tendency is in the other direction. As a sex, women are certainly less apt than men to accept the new for the sake of its novelty. The Athenians who were constantly desiring some new thing were not Athenian women, but Athenian men. Now, just as Nature with her amazing wisdom makes provision for a due supply both of conservatism and liberalism by means of the respective tendencies of youth and old age, so also does she make this provision by means of the respective tendencies of the two sexes. Very conspicuous amongst the consequences of the conservatism of women is their adherence in all places and ages to Established religion. This is a demonstrable truth of history of the most marked and salient kind, and it is by means of their support of Established religion that women at all times have most potently exercised their conservative influence upon society.

The Chief Conservative Force in Society. For now we must recognise the most important sociological truth—that the chief conservative force in all societies is the Established religion. If we ignore the relative values and qualities of different religions and simply look upon Established religion—whether Fetichism or Buddhism does not now concern us—as a constant social fact, then we may fairly argue that the most important and characteristic function of ecclesiastical institutions in general is the conservative function. In all Established religions we find the uniform conservative characters. "Every religion insists upon the peculiar authenticity of its origin, and the essential finality of its pronouncements. The official exponents of every religion have everything to gain and nothing to lose by conservatism. Every religion inclines to teach that it has already proved all things, and that nothing remains save to hold fast to that which it has proved to be good and true. Every religion goes even further. It invents a special name for variation, and, on the assumption that, perfection having been already attained, all variation in belief and practice must be bad, it calls such variation heresy, and condemns it outright. Whenever it has the power it suppresses the heretic, if possible, with such accompaniments as will serve 'pour encourager les autres.'" *But the founder of every religion was a heretic.*

Established Religion of Society. If we attempt to look upon the conservatism of ecclesiastical institutions in a really judicial way we shall recognise that, despite its evident evils, it has served great purposes. In various times and places it has made for the strength and persistence of societies. It has helped to give them that internal unity which has made them strong against external foes. Much, indeed, might be said, if space availed, in proof of the proposition that the conservatism of Established religion has been of value in the progress of society. In the present writer's judgment there is one most conspicuous instance of this. It is furnished by the Christian Church in its patronage and support of the fundamental social institution of marriage. Here is a case where "that which is good" had already been proved good by the action of natural selection through many past ages. The Christian Church, in due accordance with the conservative character which is common to all religious systems, high or low, has persistently held fast to that which is good in the instance we are considering. When the time comes to estimate the services and the disservices of ecclesiastical institutions in general, recognition will have to be paid to the incalculable service rendered by the Roman Catholic Church during many centuries by its patronage of marriage; and the true man of science will not hesitate to pay his tribute even to ecclesiastical conservatism acting upon intellectual progress.

The Greatest Battle in History. For what, when we come to think in terms of principles, is the explanation of the age-long conflict between religion and science—a conflict which has always been of great sociological interest, and which, in the present day, is perhaps the most salient of all sociological facts? Is not the answer that, while religion is essentially conservative, science is essentially liberal?

We have already contemplated the organic world and its history as the theatre of an age-long, bloody, and yet ultimately benign struggle between the representatives of the tendency to persist and the tendency to change. We have already seen cause to think that human society is also the theatre of one and the same conflict, and further, that, as in the older case, the issue of the conflict will determine the future. Now it is in the conflict between Established religion and science that we see the old struggle still waged, though now in its highest and most important form. Man is essentially a spirit, and not a muscular machine. The essential struggles of man, the essential struggles of human society, are therefore no longer mechanical or muscular but spiritual, and it is in the struggle between Conservative Religion and Liberal Science that we see the battle of ideas fought on a scale and with consequences which constitute it the Armageddon—the supreme battle—of all history.

On which side would you have us range ourselves? the reader may ask. And to this there is a sure answer. If our analogies mean anything, if it was worth while to study heredity and variation in sub-human life, if all that we have been saying hitherto is not nonsense, the answer is that we are to range ourselves on neither side. Not because we do not care, but because we are beginning to get a perception of a whole truth, and can no longer shut our eyes and fight to the death for half truths. Heredity and variation are both necessary. Conservatism and liberalism are both necessary. Each without the other would mean disaster; each is a half truth.

Half Truth is Not Truth. In all time the battle has been fought between those on either side who, so to speak, believed that the half-truth was the whole-truth, and the upshot has been that the strong and wholly true thing has ever tended to emerge, and having emerged, to persist. Now there are those to-day, as in the past, who still rank definitely on the one side or the other. There are living ecclesiastics who say that they cannot let go one word of the Bible or else the whole must go. Of all conceivable forms of "unbelief" this is surely the most horrible. On the other side are those who would utterly abolish all Established religion and all religious beliefs. For such men, whether of the one party or the other, their perception of even their half-truth is so imperfect that nothing better can happen than their mutual destruction, the speedier the better. The bigoted ecclesiastic and the bigoted atheist still survive, and though they serve no great or good purpose, at least they may show us how, in the transmutation of the struggle for life from the merely physical to the psychical, the old metaphor of battle becomes no longer applicable. It is applicable to such as these, who, indeed, would cheerfully kill each other if they could. But we shall now see that in the higher struggle of to-day there is a new and beautiful metaphor which will replace the old.

Many Roads Lead to Truth. The true metaphor to-day, we think, must be derived not from the idea of battle, but from the idea of marriage and parentage. Battle was no metaphor, but the literal truth, so long as the struggle for existence was physical and resulted in the survival of the physical. Now that the struggle for existence has been transferred to the plane of the psychical, the idea of battle is applicable only to contests between absolute truth and absolute falsehood. But reasonable persons nowadays, influenced by the great idea of toleration, are coming to see that, whatever their opinions, nothing more than approximation to the truth is possible for finite man, and to truth the many-sided there are many approaches. The wise and fruitful view, then, alike for the conservative-minded, who see the valuable aspects of established things, including religion, and for the liberal-minded, who see the need of new things and who can scarcely keep their hands off what Höffding calls "the dead values" which religions tend to drag about with them, is that nobly expressed by Spencer in a passage which we have already quoted. It is the idea of union consummated between the truth partially perceived by one type of mind and yet another truth partially perceived by another, the fruit of such a union being a yet higher and deeper truth that neither side could formerly perceive. Thus, at last, we may be "led into all truth," and so attain the goal of the mind of man.

The Factors of Progress. And this, to our mind, expresses the highest worth of the principle of toleration. It is not merely that the practice of toleration removes from society its most appalling evils, such as religious persecution and the wars of religion, but it makes, as no other condition can make, for our advancement towards the goal of truth. There is scarcely a more terrible revelation than that which the mind attains when it asks what point humanity would now have reached if throughout merely the brief period of recorded history the characteristic conservatism of savagery had been completely complemented by the practice of toleration. What is it that has conditioned the progress which even recorded history demonstrates?

Certain things may be excluded. There has been no advance of the slightest moment in the physique or the bodily characters of man. Secondly, there has been no advance, or no demonstrable advance, in the inherent psychical qualities of man. The baby born in the twentieth century after Christ would, on the average, be neither above nor below the average if it could be transferred to a nursery of three thousand years ago. The achievements of the Greek mind have yet to be surpassed; the present age, with its manifold advantages, has not yet beaten the Greek record. Indeed, it is beyond dispute that all mere biological or physiological reasons to explain the recorded progress of the historic epoch are lacking.

Man and His Social Conditions. There remains only the supreme fact that in each generation some psychical conquest is recorded—not merely some intellectual conquest but some psychical conquest, whether Newton's "Principia" or "Hamlet" or the record of a noble life—which becomes a permanent possession of the human mind and the human race. For thousands of past years the inherent characters of man, necessary for the winning of such victories, have been present. It is to the social conditions which have surrounded him that we must turn for an explanation of the fact that we, in this age, have not already reached such psychical heights as we may hope for our descendants of the year 5,000. Organic or physical evolution is an exceedingly slow affair. Hundreds of thousands of years are necessary for the contemplation of the history of definitely recognisable man. The period in which progress has been made from barbarism to civilisation is a mere nothing in the whole history of man, and the only explanation of its brevity and the magnitude of its achievements therein is to be found in the development of those conditions which have enabled individuals to make psychical

conquests and to endow with them not their own time alone, but all future generations.

The New Must Get a Full Hearing. For the most rapid advance of man, then, we need, primarily and essentially, the perfect realisation of those conditions, of which the imperfect realisation in the past has already sufficed for so much, though not for a tithe of what might have been. This is to say that, at all costs and under whatever external form of government, we must have a society in which the new gets a full hearing, and in which the conditions for the production of the new are as favourable as possible. The new is not good because it is new, nor yet is it therefore bad; neither is the old good because it is old, nor therefore bad. We must prove all things, new or old. In a savage society there may conceivably arise an observer of nature who would endow his tribe with new powers, but such a society is not conditioned for the production of the new. It promptly kills the inventor as a sorcerer or servant of the devil. Again, in such a society as that which France witnessed scarcely more than a century ago the old, however good and true and tried, was condemned simply because it was old. Either state of affairs is as fatal as the other.

We are attempting, as the reader observes, to encompass an infinite subject in the briefest of spaces. Our business, therefore, has been, as far as possible, to deal with principles, though we propose, before closing, to show how sociology must attack a definite concrete problem. When the choice lay between attempting to expound the principles which we have just discussed and, on the other hand, attempting a serial study of various well-marked forms of government, we could not doubt which to choose.

We Must Know What We Aim At. If we are to believe in science at all we must believe in the existence of principles, and if we do so we cannot be excused for ignoring them. We may leave to untrained minds the common forms of the controversies as to monarchy or oligarchy, democracy, the hereditary principle, and so forth. This is not that we are so foolish as to deny the immense practical importance and interest of these subjects, but it is that, as students of science, we entirely repudiate the common methods of approaching these problems. It must never be forgotten that, as we have pointed out, the sociologist has a purpose; he desires not only to discover what is, but, with the moralist, to discover what ought to be; and, lastly, to discover how what is may be transformed into what ought to be. Until you know what you are aiming at what is the use of arguments about democracy and monarchy?

The truth is that only among the very few has the evolutionary idea yet established itself. The majority still think of society statically, whereas the evolutionist must think of it dynamically, as he does of every other fact in the universe. Society for him is a something which moves, which has come from somewhere and is going somewhere. The pre-evolutionary thinker will take a given nation—a monarchy, perhaps—and will inquire whether monarchy "works" there. To his eye the people seem prosperous and contented. Very well, then, he will answer, monarchy suits them and is the best form of government for them. To the evolutionist such talk is the prattle of a blind baby. He knows that the static stationary society, though it may seem stable, is, relatively to the motion of all things, a decadent society. It, too, is moving, and moving downwards. The evolutionist cannot content himself with *now*.

Man Has Forever. The true answer of the evolutionist, we think, to those who study society merely for the present, who do not ask where we are going, and who do not realise how awful is the difference between what is and what might be—even amongst "a happy and prosperous people"—is to be found in a phrase from Browning's great poem, "A Grammarian's Funeral":

> "Leave Now for dogs and apes!
> Man has Forever."

Man has a future, compared with which his now is verily a now of dogs and apes. If there be those who find it in them to be contented with any society now extant or already extinct, *we* are not of their number. We have ideals; we have studied the past, not as men read gossip nor as they read a new novel, for its "strong human interest," but because we believe that in studying it we may discover principles which are no less than the principles of progress, and having learnt certain of these principles we propose to keep them steadfastly before us in studying all contemporary social problems—including, for instance, forms of government. Furthermore, those principles must be our criteria or means of judgment, and we shall ask of any form of government, not "Do the people like it?" not "Does it please the Chancellor of the Exchequer?" but "*Does it open or close—does it make broad or narrow—the onward way?*"

The Great Controversy of To-day. In the light of these principles, let us attempt briefly to discuss the present great controversy, practical and theoretic, between individualism and collectivism. Each of these words is capable of a good and bad interpretation. They mean different things in different mouths. But we shall endeavour here to make reasonable interpretations of both, and to see whether these ideas cannot be judged in accordance with our principles and whether, also, they do not each of them contain a truth, or half-truth, the union of which with the other would be fruitful of good.

It is this controversy, and not the controversy between the principles of monarchy and democracy, that really concerns society to-day. There may have been a time and a place for monarchy, but neither is afforded by the progressive peoples of to-day. It need hardly be pointed out that our own country is a monarchy only in name. We shall ignore Russia, therefore; and we shall also ignore Germany, which will become a progressive people in any real and great sense only when she has done with her abominable burden of militarism. We may

confine ourselves to England, France, and America—peoples on the whole, despite terrible lapses, pacific and progressive, all alike essentially democratic. The common argument in discussing these large matters is an argument for and against democracy; but that is really out of date. More especially is it out of date, because it concerns itself with the form and not with the substance. The mere democratic form is not the vital thing. In our study of human nature and society have we not seen that even a military autocracy depends upon the will of the people who provide their autocrat with his army, thus almost warranting the idea that such a form of government is, in a sense, democratic? The really vital question is not the external form of government at all, but the mutual relations of the individual society.

The Two Kinds of Democracy. Thus it is possible to have two mutually opposed forms of democracy which, though under the same name, yet offer the most fundamental opposition that society can conceivably show. When we realise this we shall realise how absurd is the current argument for and against democracy, as if democracy were always one and the same thing. On the one hand, we may have an ultra-individualistic democracy, and on the other an ultra-collectivist democracy. Now, these are the two ultimately opposed forms of society. The supposed difference between autocracy and democracy is nothing compared with this vital and fundamental difference between democracies themselves.

We may take the United States of America as a fairly typical example of the one extreme. There, we find a society which regards individualism, utterly disqualified, as the only true social principle. There liberty becomes licence. The new certainly gets a hearing; personal energy and initiative are rewarded; but there is no qualification of this principle by its correlative half-truth. The individual is allowed, in the exercise of his liberty, to destroy not only the liberty but also the lives of his less able or energetic or fortunate fellows. And the social state approaches to anarchy. This is not the ideal anarchy of the future, when, human nature at large having reached the heights which now only the few attain, each man will live by an inner law that impels him to serve all others, but it is the anarchy of human nature in its present state, which is indeed lower than the angels.

The End of the State is Justice. On the other hand, certain parts of America, and certain aspects of life in England and France, afford us hints of the other social extreme. The nominal label, in the case of France, at any rate, is still democracy. But we here have forsworn labels and label-makers, and may get on to facts. In the ultra-collectivist state, which is represented now only by a very few barbaric tribes, but which played a great part in the early history of society, we find the chief character to be the absolute rule of all over each. The individual is the slave of the society; he must do as he is told for the good of the whole—this involving the amazing assumption that majorities are always right. The slave, of course, is a slave, whether his master be an individual, a bureau, or a mob. And the slavery of the individual to the tribe in primitive societies is, we may venture to say, not merely a noteworthy fact of such societies, but the explanation of the fact that they are primitive.

How, then, are we to frame the ideals of liberty and justice which combine the half-truths seen by these two extreme forms of society—the half-truth that the individual must be allowed to express himself and the half-truth that the individual, as we now know him, cannot be a law unto himself? We shall find what we desire in the great formula of justice laid down and magnificently elaborated by Herbert Spencer. The end of the State, he said, is justice, meaning thereby exactly what Lord Acton meant when he said that the end of the State is liberty; and justice is constituted when "*Every man is free to do what he wills, provided he infringes not the equal freedom of any other man.*"

The Music-hall Type of Mind. The primitive idea of justice is that of aggression and counter-aggression; if you have your fists free, I may hit you, for cannot you hit me back. That primitive notion, which is still found in the music-hall and in the music-hall type of mind, has nearly vanished, and there remains the great idea expressed above, which constitutes the ideal that selects, recognises, and mutually complements the partial truths expressed by absolute individualism and absolute collectivism.

Continued

CENTRAL TELEGRAPH OFFICE

Continued from page 5395

Repeaters. Accumulators. Correct Time for the United Kingdom. London's Telegraph Intercommunication Switch. Post Office Statistics

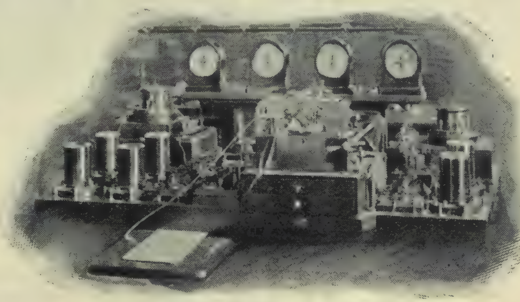
By D. H. KENNEDY

Repeaters. As the length of a telegraph line increases it is found that the speed at which signals can be transmitted through it rapidly decreases. It is, in fact, inversely proportional to the capacity per mile, and also inversely proportional to the resistance per mile, and as a consequence the signalling speed varies inversely as the square of the length of the circuit. When, therefore, the length of a circuit is so great as to reduce the speed below the maximum rate for the instruments, recourse is had to the use of repeaters—that is to say, the circuit is divided into two, and an intermediate instrument introduced which, on being affected by the signals from one section repeats them to the other, and *vice versâ.* In signalling from London to Edinburgh a repeater is introduced at Leeds, and in signalling from London to Dublin a repeater is introduced at Nevin, on the Welsh coast. The repeater is introduced at a point so that the products of the capacity and resistance of the sections on each side of it are as nearly as possible equal. In principle, it is merely an extension of the relay [see page 5067].

Figure **76** illustrates one of the most complicated forms. It is a forked repeater such as is used at Edinburgh on the news circuits already described; the wires from Glasgow on the west, and Dundee and Aberdeen on the north, meet at Edinburgh at the forked repeater, which is also connected to London. Another repeater is introduced on the same circuit at Leeds. As an interesting instance of the extent to which repeater working is possible, it may be stated that the Indo-European Telegraph Company maintain direct Wheatstone working between Manchester and Teheran, in Persia, by means of 11 intermediate repeaters.

77. CENTRAL TELEGRAPH OFFICE, LONDON—ACCUMULATOR ROOM

Batteries. Until quite recently all telegraph circuits were worked by means of primary batteries, and at small offices this is still the case. Three main forms have been used—the Daniell, the Leclanché, and the Bichromate. These have already been described on page 465. The Daniell cells were used for local circuits—that is, between the sounder and the relay, and for such cases as duplex, where a constant current is required; Leclanché cells for needle circuits; and for long circuits, where the current consumption was considerable, the Bichromate was utilised. In determining the number of cells required for a given circuit, allowance has to be made for the resistance of the battery, as well as for that of the line and instruments, and a formula



76. FORKED REPEATER

developed from Ohm's law [see page 61] is usually employed for this purpose. It is as follows:

$$N = \frac{CR}{1000E - Cr}$$

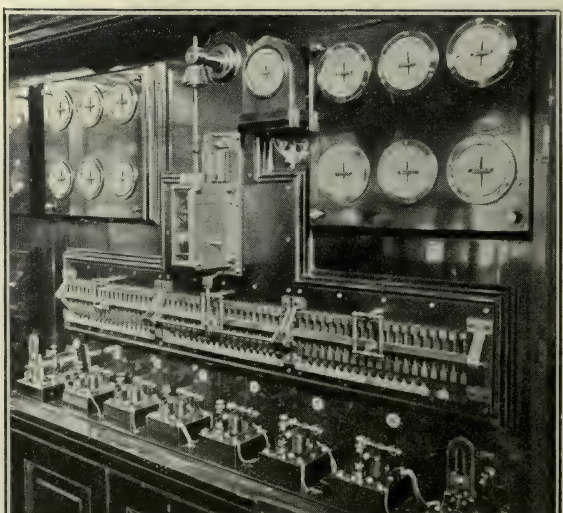
where N is the number of cells required, C the given current in milliamperes, R the total resistance of line and instrument in ohms, E = the electromotive force per cell in volts, r = the resistance per cell in ohms.

Accumulators. In all large telegraph offices primary cells have been displaced by accumulators, the change effecting a great economy in space and in cost of energy. Figure **77** is a very interesting view of the accumulator-room at the Central Telegraph Office, St. Martin's-le-Grand. It contains altogether 800 cells, and when these were introduced in 1899, no fewer than 23,000 primary cells were displaced. Accumulators have already been dealt with on page 3086. It will be of interest to refer to some other features of the Central

78. PART OF BASEMENT TEST FRAME AT CENTRAL TELEGRAPH OFFICE, LONDON

Telegraph Office, and it may be stated that the Secretary of the Post Office kindly allowed a special series of photographs to be taken for this publication. When the Post Office took over the telegraphs in 1870, 230 wires were led into the Central Telegraph Office; this number has now increased to 4,300, and special means have to be adopted for their proper handling. In **78** is shown a section of the basement test frame. The wires are first brought to the further side of it, which is not visible in the illustration, and arranged on horizontal bearers. They pass through this frame to the front side, where they are soldered to vertical strips of combined test springs, lightning protectors, and heat coils. These are all numbered so that ready access can be had to any wire for testing at this point. The wires are then distributed to the various galleries, and **81** shows the provincial test box on the third floor. The rectangular tablets are of ebonite pierced by small brass cylinders, the incoming wires are soldered to the rear of alternate horizontal lines on these cylinders. The cylinder above each line is connected to the instrument set, and on the front of the test-board two cylinders are connected together by the insertion of a small aluminium "U" link, from which this type of test box takes its name. A still later form of test box is shown in **80**. This is in one of the divisions, and it is made up of switch springs of the telephone form to be described in a later section. These take up less space than the "U" link form, and permit of greater flexibility.

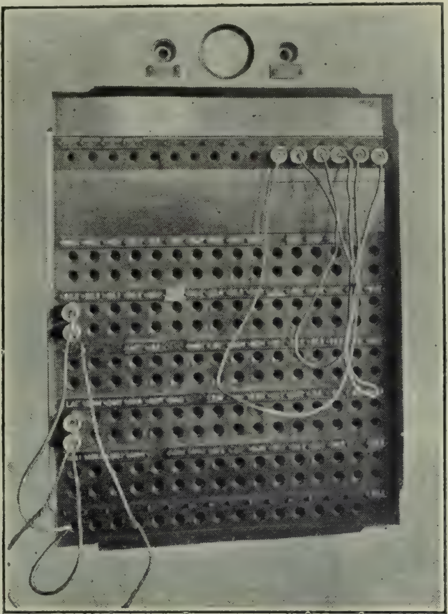
Correct Time. In **79** is shown one of the most interesting features in the Central Telegraph Office. It is called the *chronopher*. One line to each of sixty of the principal towns in the United Kingdom is carried through the set of switches which can be seen extending across the front of the board. Normally, these are connected through to the working sets. At two minutes to ten each morning the clock mechanism visible above the switches comes into action and slowly presses forward the long, horizontal busbar until these 60 lines are disconnected from the working sets and connected up to the special relay visible on the extreme left, which is in communication with Greenwich Observatory. Precisely at the hour of ten a current is received from Greenwich, which affects the time relay and sends out currents to master clocks, town clocks, and time guns situated at the towns aforesaid—as far north as Aberdeen, south-west to Penzance, and west to Waterford. Exact Greenwich time is in this way disseminated throughout the kingdom. The same current which actuates the chronopher relay passes on to Westminster and controls Big Ben. For towns other than those mentioned a less precise system suffices. Six repeating sounders are fixed on the front of the chronopher, and they are connected with various bells in the divisions which strike at the hour, so that the telegraphists, who are on the alert, can transmit the word "ten" to all the smaller towns. This same human relay system is in operation at all the provincial offices, so that the



79. CENTRAL TELEGRAPH OFFICE, LONDON—THE CHRONOPHER

chronopher instrument may be regarded as the centre of an immense spider's web, along every fibre of which at ten o'clock every morning a thrill passes.

London Intercommunication Switch. Until 1902, the system of centralisation and retransmission which has been described in connection with provincial circuits also prevailed in connection with London's own intercommunications. A telegram handed in at any suburban office was transmitted to the Chief Telegraph Office, and, after traversing its mazes by tube or by hand, reached another suburban circuit and was retransmitted. The competition of the telephone, with its prompt switching and instantaneous communication, made itself severely felt, and it became obvious that means must be found to shorten the time necessary for inter-city telegraphic communications. In accordance with modern methods, the telegraph took a leaf out of the book of its adversary, and an intercommunication switch on telephone lines, equipped with lamp signals and arranged for central energy working, was introduced. More than 300 London telegraph offices have been connected to it, and others are being rapidly added, and as it permits of direct communication between any two connected stations it is obvious that a great saving of time and also of staff has resulted from its adoption.



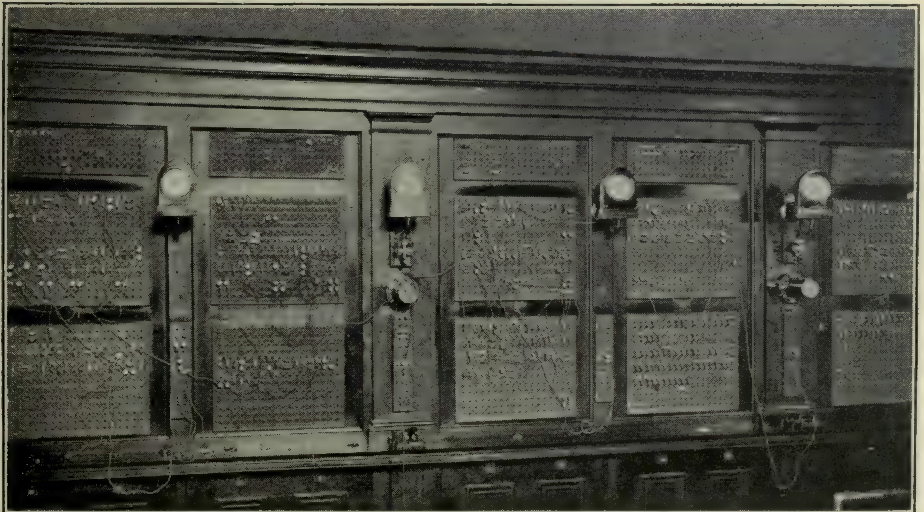
80 TEST BOX (SWITCH SPRING TYPE) AT CENTRAL TELEGRAPH OFFICE, LONDON

The Old Metropolitan Division. Under the old arrangements, the London suburban and branch offices, numbering nearly 500, were connected to instrument sets forming the Metropolitan Division. At four "check" tables, one at each corner of the building, the messages were sorted and marked for distribution by a staff of clerks whose knowledge of London's geography and the corresponding telegraphic avenues was simply stupendous.

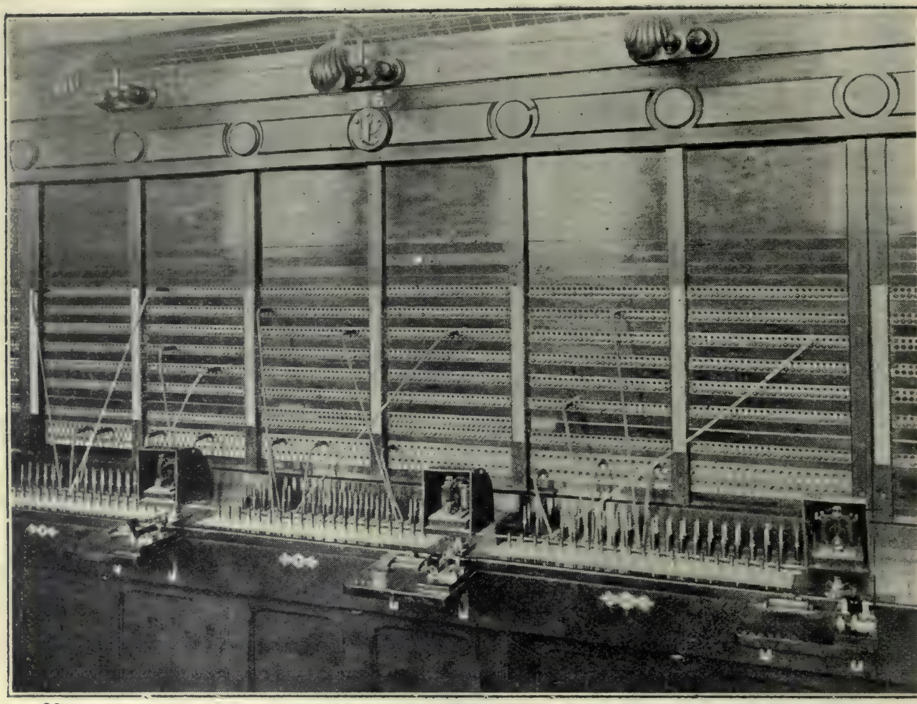
In the year preceding the introduction of the switch the Metropolitan Division had a daily average of 102,000 transactions, of which number 54,000 were due to the reception of 27,000 messages *from*, and their subsequent transmission *to*, London offices. The new switch aims at eliminating the whole of these 54,000 transactions and at the same time effecting economies of time and space and plant.

Provision will ultimately be made for 300 switch wires to offices which collect only, 650 switch wires to offices which collect and deliver, and 200 circuits for receiving messages will be provided, making a total for the switch of 1,150.

The Morse sounder system is employed throughout, and this has necessitated changes at many offices and the training of the staff.



81. TEST BOX (U-LINK TYPE) AT THE CENTRAL TELEGRAPH OFFICE, LONDON



82. SECTION OF LONDON INTERCOMMUNICATION SWITCH FOR SUBURBAN AND CITY OFFICES

POST OFFICE TELEGRAPHS AND TELEPHONES IN THE UNITED KINGDOM.

	1901.	1906.
A.B.C.	5,817	4,929*
Needles, Single and Double	4,837	2.103
Bright's Bells and Double Plate Sounders	1,106	402
Printers, Simplex	507	363
Sounders, Simplex	3,699	7,408
Duplex (exc. of Wheatstone)	1,674	1,5[illegible]2
Quadruplex	35[illegible]	537
Multiplex (Delaney)	22	1
Wheatstone (including Duplex)	5[illegible]9	585
Other Kinds	4,003	8.095
Hughes	112	104
Telephones	12,668	58,472
Telephone Switch Sections, Test Board, etc.	704†	5,772
Signalling Bells	1,643	3,110
Repeaters	151	163
Total	37,952	93,596

* Includes 83 Steljes' Recorders. † Switch sections only.

Circulation Lists. It has also been necessary to supply to each of the offices two circulation lists, one containing names of streets, etc., and the other registered telegraphic addresses. The first of these contains no less than 30,000 entries, and the second 23,000. Figure 82 shows one section for three operators, and there are ten such sections. The bottom panels are occupied by glow lamps having switch springs above them to which circuits are connected.

Switch Offices. At each of the out stations there are a sounder and key and also a special key used only for calling the switch operator or for effecting a "clear" signal when finishing. It has a side plunger which actuates a star indicator when a call is made by its momentary depression. The star indication remains visible until the switch operator connects her sounder to the wire, when it disappears.

In concluding this Telegraph section, it will be of interest to give United Kingdom statistics for Post Office telegraphs and telephones for the years 1901 and 1906. They show at once the extent of and the trend of development. Telephones are included, and the great increase in the figures in these cases and also in those under the head of Underground is, of course, due to the development of the London telephone system.

MILEAGE OF PUBLIC AND PRIVATE WIRES, SUBMARINE CABLES, AND PNEUMATIC TUBES, AND THE NUMBER OF INSTRUMENTS IN THE UNITED KINGDOM ON THE 31ST MARCH, 1901, AND 1906.

Year.	Mileage of Line.				Mileage of Wire.			
	Overhead.	Underground.	Submarine.	Total.	Overhead.	Underground.	Submarine.	Total.
1901	42,088½	1,219¾	3,133½	46,441¾	285,790½	51,361¼	11,267¼	348,418¾
1906	47,862¾	3,102¼	3,615¾	54,580¾	355,482	318,700¼	13,269¼	687,451½

PNEUMATIC TUBES.—1901 : 62¾ Miles. 1906 : 74¼ Miles.

TELEGRAPHS *concluded ; followed by* TELEPHONES

NATURE AS A DOCTOR

Ill-Health and its Symptoms. Nature's Efforts to Keep Us Well. Symptoms and Treatment of Disease. False Systems of Treatment. Remedies

Continued from page 5412

By Dr. A. T. SCHOFIELD

WE shall, in due course, speak of the general features of disease, and go at some length into the various causes that produce it. We shall here consider the *symptoms*, the *diagnosis*, the *prognosis*, and the *treatment* of disease from a general standpoint.

The Symptoms of Disease. In the first place, there is no means of telling that a person is in ill-health at all but from symptoms. This is of great importance. These symptoms, or signs, are evidence that the man is ill. But this is only half the truth concerning them—the half with which we are most familiar. The other half, of which most of us have never heard before, is that symptoms also tell us if the patient is already being treated scientifically, and that *these symptoms are the very remedies that are being used for his cure.*

Symptoms arise from two causes. One set is the result of the illness itself, such as weakness, collapse, delirium, pain ; another is the result of the actual methods of cure adopted by the *vis medicatrix naturæ*—the unconscious mind—for the relief of the sufferer. Such are temperature, cough, sweat, nausea, loss of appetite. There is a sense, indeed, in which *all* the symptoms, including even the weakness, pain, and delirium, may be regarded as protective and beneficial, even if not actually curative.

Symptoms, therefore, may be regarded, as a whole, as produced by the central governing force, partly for the protection and partly for the cure of the patient, and are, with few exceptions, beneficial and remedial. This is possibly new to a great many people, whose first idea in connection with a high temperature, for instance, is to lower it, or with a cough to stop it.

Nature's Treatment of Ill-health. Let us take two cases as illustration. A lady is sitting at dinner, when she is suddenly invaded by the germs of pneumonia. Symptoms at once set in. She shivers, her temperature begins to rise, and she gets into a fever. This tends to kill the germs and destroy their poison. She feels ill, and must leave the table ; this is to make her acquainted with her state. She must undress and lie down ; this leaves her lungs free and puts her at rest. She cannot do with light and noise ; this ensures rest. She refuses all solid food ; this is because she can no longer digest it. She bursts out into profuse perspiration ; this is to prevent the fever from rising too high. She begins to cough ; this is to keep her lungs free. Her breathing becomes more frequent ; because it is shallow.

Here, then, are a number of symptoms, none of which a wise physician will interfere with, for he knows very well they are all beneficial. He may have been taught to "treat" them, but if he be wise the only way he will treat them is with respect.

The other case was given by Sir. F. Treves at Liverpool, and is of appendicitis. Here, indeed, every attack must prove fatal but for the rapid curative symptoms that supervene. The temperature again rises to kill the germs ; the bowels cease to move to give rest ; the abdomen becomes rigid to protect the tender area ; an abscess forms to prevent the poison spreading ; pain is felt at the spot to indicate the locality, and so on. All symptoms are beneficial, and represent Nature's efforts to cure the disease.

We will now briefly review the various classes of symptoms, which form two great divisions—the *subjective*, or those observed by the patient ; and the *objective*, or those noticed by the doctors and others. We may divide the subjective symptoms into five classes—*sensory*, *motor*, *functional*, *mental*, or *phenomenal.*

The Great Value of Pain. The first of these symptoms is pain. Consider for a moment the value of pain. It is as useful as the red light on a railway. Where it is absent we are in imminent danger. A man who has lost feeling in his legs may burn them severely when asleep before a fire. The heart having no sensation, severe disease can develop unknown to the patient. Pain at once says something is wrong, and indicates the locality; without it we should not be safe for a moment.

It is of the greatest importance to have the seat, character, duration, and intensity of the pain accurately described. It may be boring, darting, cutting, dull, throbbing, or aching. It may be general or local. It may be fixed or shooting, constant or intermittent, severe or slight, superficial or deep. There may be tenderness in the part, or pressure may relieve it. As a rule, we say that sharp pains which are relieved by pressure are less serious than dull pains made worse by pressure. The sensations may not be those of pain, but of uneasiness, nausea, cold, with shivering (this is important), or of heat—general or local. Or there may be other sensations —a "ball" in the throat or stomach, irritation, aching, fulness, malaise, weakness, giddiness, or loss of sensation, partial or complete.

Amongst the *motor* symptoms are paralysis, partial or complete, generally described as local, stiffness, weakness, lassitude, involuntary, spasmodic, or painful movements, etc.

Functional symptoms include every irregular or imperfect action of any organ or special sense. The ears or eyes may be deaf or blind. There may be loss of smell or taste ; the breathing may be laboured, short, hurried; the heart may

palpitate or beat irregularly, and so on with every organ.

Among *mental* symptoms there may be delirium, mania, monomania, confusion, loss of memory, unconsciousness, excitability, apathy, despondency, and so on.

Under the head of *phenomenal* symptoms may be grouped definite states or acts that cannot otherwise be classed, such as cough, sickness, blood-spitting, running from the ears, formation of boils, tumour, or states such as bilious.

The greater part of these subjective symptoms are of a curative nature, as we have already seen. The remainder are the direct result of the disease. All seem to indicate the special illness the patient suffers from.

How Disease is Detected. We now turn to objective symptoms of disease—those observed by others. Our means of observation are sight, hearing, touch, smell, and experiment.

We notice first the general aspect and expression of the patient, the colour of the skin, the presence and character of any eruptions, the expression of the face, denoting ease or suffering, depression or excitement, the condition of stoutness or leanness, or wasting or bloodlessness, and many other matters. It is, indeed, here that the habit of rapid and accurate observation is so invaluable.

We must also notice the position of the patient —how he lies, sits, or stands, and how he breathes; the appearance of the eyes, of the tongue, and so on. The pulse, however, has now by no means the importance that it had before the days of exact observation.

Hearing tells us the character of the breathing, the voice and speech of the patient, including cough and its character, hoarseness, etc. But the ear is of special value when aided by the stethoscope, to hear and understand the sounds in the lungs, heart, stomach, etc. We notice also resonance or dulness by percussion.

Touch is an important means of objective diagnosis, and reveals many symptoms. We get a knowledge of the temperature, of moisture, of dryness, of size, shape, elevation, or depression of any part. We notice smoothness or roughness, pulsation, vibration, extent of movement, resistance, softness and hardness, and fluctuations, by which the presence of fluid is detected.

Smell and taste may reveal symptoms in certain cases. The general odour is often significant, and the special odour from any diseased part reveals decayed lung, cancer, etc.

Experiment includes weighing the patient, examining him with instruments, such as measures, thermometer, ophthalmoscope, laryngoscope, auroscope, specula, sounds, etc.; also by chemical tests of all sorts, and by electrical tests.

Nature's Unceasing Effort. Before leaving symptoms, the writer would repeat that Nature (the unconscious mind) is ever in disease seeking to adapt the disturbed balance of life to the environment, and causes the symptoms. Take the case of rheumatic fever, which is Nature's effort to get rid of a powerful blood poison, brought on by indigestion, bad air, cold, and damp. In doing so, one of the valves of the heart may get thickened, and cease to act perfectly. Nature therefore gradually enlarges the heart to meet the extra strain upon it, and the man suffers from an hypertrophied heart, a symptom which, so far from being hurtful, actually keeps him alive. If he be wise, he helps Nature by giving her less work to do by henceforth only "eating to live," instead of "living to eat," and all goes well. In fact, if the heart is overloaded, Nature makes another effort, and produces dropsy as a safety-valve to relieve the heart from too much weight of blood. This is another symptom beneficial in itself, but pointing, of course, to a grave danger. If the man still persists in his folly, Nature, having failed to adapt the life to its environment, has nothing left but to cease its efforts in the silence and stable equilibrum of death.

Danger of Interfering with Nature. While, therefore, we cannot observe too keenly and accurately the subjective symptoms in ourselves, or the objective symptoms in others, we cannot be trained to interfere too little; and this review of symptoms will be of great value if all who read it learn one lesson. The extent to which any interference is wise in domestic life will be considered in connection with the various diseases. These symptoms, ascertained by what the patient reveals, and what we are able to observe by physical examination, form the basis of our diagnosis.

The art of recognising the presence of disease, and of ascertaining from what form of disease a patient is suffering is known as *Diagnosis*. It is a matter of great interest and importance, for as it is founded on the symptoms and history of the disease, so it forms the foundation for prognosis and treatment; and the correctness and success of these entirely depend upon the accuracy of the diagnosis.

Only the simplest forms of disease can be recognised by the laity, and these not with certainty, so often is the meaning of symptoms misunderstood. A high temperature in a little child may not mean fever, but only a gastric disturbance; a pain in the heart in the same way may arise from flatulence, and so on. To form a correct diagnosis, therefore, is almost impossible, save to a medical man, and even he is often mistaken.

The Treatment of Disease. The foretelling of the course of disease is called *Prognosis*. Though a matter of the greatest importance to the sufferer, it can seldom be given exactly. One can often tell if a disease is curable or not; but the length of time it may take and the means that may have to be used depend on so many factors that great accuracy is impossible.

We will now consider the nature of the various remedies and systems of treatment. The old-fashioned way of classifying remedies and treatments was according to the effects they were supposed to produce. First of all, however, they were divided into two great divisions—*rational*, or those which produced effects by

means we could understand and trace in the system; and *empirical*, or those which produced undoubted effects, but how we know not. Every physician employed both these classes of remedies; but, of course, the more he employed of the first division, and the less of the second, the greater the credit.

False Ideas of Treatment. Further, remedies and treatments were classed according to their supposed effects. We thus had *expectant* treatment, which really was most enlightened, and under other names is widely used to-day. It is founded on the principle that the *vis medicatrix naturæ* is often the only physician needed, the doctor neither assisting nor interfering with its operations, but only taking the fees. This system, good and enlightened in principle, becomes dangerous, and even fatal, in those cases which require immediate and prompt action. It has been the writer's lot to stand by a man's bedside and tell him he must inevitably die within a fortnight from complete blocking of the large bowel, due to his constipation having been treated on the expectant system.

The next form was *palliation*, which consisted in using means calculated to soothe and lessen suffering in those cases where a cure was not possible, but where life might be prolonged.

The *stimulant* treatment was founded on a doctrine that regarded most diseases as associated with, or dependent upon, a lowered state of the vital powers, and which required, amongst other things, a free and constant use of alcohol. One hospital physician, whose practice was founded on this treatment, often gave a bottle of spirits a day to cases similar to others that were more successfully treated in other wards without stimulants at all.

Obsolete Systems and Modern Views. The *lowering* (antiphlogistic) treatment is the opposite of the foregoing. It considered that very many diseases were due to over excitement and fulness of blood, and treated these by bleeding, blisters, purging, and the like. This was the most fashionable treatment in the seventeenth and eighteenth centuries, and it would be hard to say how many died from it.

The *elimination* system has more to recommend it, regarding disease as some poison introduced into the body, to be got rid of through the skin, kidneys, or bowels. The *hydropathic* system is largely founded on this.

The *alterative* system looks on diseases as vicious habits, which must be broken by violently "altering" the "course of Nature" on the "habit of the body." This system always employed very powerful drugs, often in dangerous quantities, such as mercury, arsenic, iodide of potassium, and the like. There were other systems, but these were the best known. In these days, such a classification is practically obsolete, and even the words empirical and rational are archaic. We are no longer sure that we can trace the real course of the action of drugs; we find the processes more complicated than we thought; and, besides all this, we are beginning to see that the action of no drug is purely physical, dependent solely on its chemical composition, but that we have to take into account constantly the personality and state of the individual at the time, the amount of his vital power, and his nervous system, on which the efficacy of the drug partly depends.

Three Classes of Remedies. The simplest practical classification of remedies is according to their *nature* rather than their supposed *action*.

The division on this principle would be into three classes: *pharmaceutical* remedies, or drugs; *natural* remedies, which would include all mineral waters and spas, travel, climates, use of water, air, light, heat, electricity, etc., in every form, all sorts of physical exercises, including massage, riding, cycling, motoring, etc.; and, lastly, *psychic* remedies, which include every curative form of mind action. Let us take a brief but comprehensive survey of these three classes of remedies.

Here we must distinguish again between the rational use of drugs, which constitutes a science, and their empirical use, which is an art. Of course, the success of the treatment must depend, as we have said, on the accuracy of the diagnosis.

Until the last fifty years the most fanciful ideas prevailed both with regard to disease and drugs. The former were attributed to all sorts of processes and changes, wholly imaginary, that were supposed to take place in the body. The latter were credited with all sorts of fanciful properties, some being called hot, some cold, some contractile, some relaxing, some alterative; while some were considered of value owing to their noxious composition or taste, or their fanciful resemblance to the part affected. All this has long since given place to the *experimental* use of drugs, by which their exact effect was proved by experiments on animals, etc.; but the problem of the real action of drugs is so complex that pharmaceutical therapeutics will probably never become an exact science.

The Best Physician. In spite of the multitude of synthetic compounds made in America and Germany, laboratories for special diseases, by which our ordinary pharmacopœia is supplemented, the general use of drugs is less, and dependence on their effects not so great. The greatest physician in these days is the one who closely observes the action of the unconscious mind and copies most nearly the curative processes of Nature, using drugs sparingly, and never without a definite reason.

Amongst drugs which still hold their own as having a real specific value may be named various salts and compounds of mercury, arsenic, lead, sodium, potassium, iodine, chlorine, phosphorus, sulphur, carbon, iron; acids of various sorts; vegetable extracts, such as quinine, strychnine, opium, belladonna, digitalis; laxatives of all sorts; colchicum, podophyllin, euonymin, caffein, in addition to the swarms of artificial compounds, such as antipyrine, chloral ether, chloroform, phenacetin, paraldehyde, sulphonal, etc.

Con'inued

Group 8
DRAWING
39
TECHNICAL DRAWING
continued from page 5421

DRAWINGS FOR A HOUSE

Preparing Contract Drawings. Site Plan. Plans of Floors and Roof. Elevations. Sections. The Staircase

By R. ELSEY SMITH

CONTRACT drawings form the basis on which estimates of the cost of carrying out any work are prepared, and are signed as forming an integral part of the building contract. They include a complete set of general drawings and sometimes detail drawings of portions of the work; the former are prepared usually to a scale of 8 ft. to 1 in., but sometimes, in the case of small buildings which are plain in character, to a scale of 4 ft. to 1 in. When drawings are made to the latter scale it is possible to show most work of a simple character with sufficient clearness to make detail drawings unnecessary except full-size details of all moulded work or special ornamental features.

General and Detail Drawings. When the general drawings are made to the scale of ⅛ in., detail drawings are required drawn to a scale of 2 ft. to 1 in., or, as it is more generally referred to, of ½ in. to 1 ft., or sometimes to larger scales for elaborate details; it is useful and desirable that some such detail at least should be included among the contract drawings; the more complete these are the less will be the likelihood of variations during the progress of the work.

Contract drawings are usually made on paper, finished in ink and fully coloured. This was the universal custom till recently; but now in some cases the drawings are carefully finished in ink on tracing paper or linen and then copies are made from them by use of the sun-printing process, and a set of these are fully coloured to form the contract drawings; other copies being supplied to the builder and, if necessary, to any sub-contractors.

This method of securing several copies from a single tracing is a great economy of time and labour, the principal drawback being that only black lines can be thus reproduced, and that, with some processes at least, there is a slight shrinkage noticeable in the copies. It is therefore very necessary when a tracing is to be reproduced by photo process that dimensions should be fully figured and the scale drawn on the sheet.

The Plan of the Site. The first step in preparing drawings for a building is to secure an accurate plan of the site. This is sometimes supplied to the architect, but must be checked. Often there is no such plan, and the site must be surveyed—a somewhat troublesome matter if it is already built upon. In towns where the whole site is to be covered with buildings the plan may be laid down at once to the scale to which the drawings are to be prepared; but in more open sites the ground may be plotted to a smaller scale depending on the size of the estate, but a scale of 22 ft. to 1 in. is often adopted. This plan should show the boundaries of the site, any buildings on adjacent sites that may affect the position of any new building near them, all buildings actually occupying the site, the north point, and any roads or paths. It should show the position and levels of any public sewers to which buildings on the site may be drained, and, where they can be ascertained, the situation of gas, water, and electric mains. The levels should also be indicated either by means of section lines or by a series of figures showing them at various points in relation to some well-defined datum line [**5**]. The levels of a site and the question of aspect have an important bearing on the planning in many cases.

A full set of contract drawings should include the following drawings:

A plan of the site. This may be to a smaller scale than the plans of the buildings, and on it the drainage is often shown.

Plan of the foundations. Drains are shown on this, if not on the site plan [**7**].

Plan of every storey in the building [**6**, **8**, **9**].

Plan of the roof.

Elevation of each front of the building [**10** and **12**].

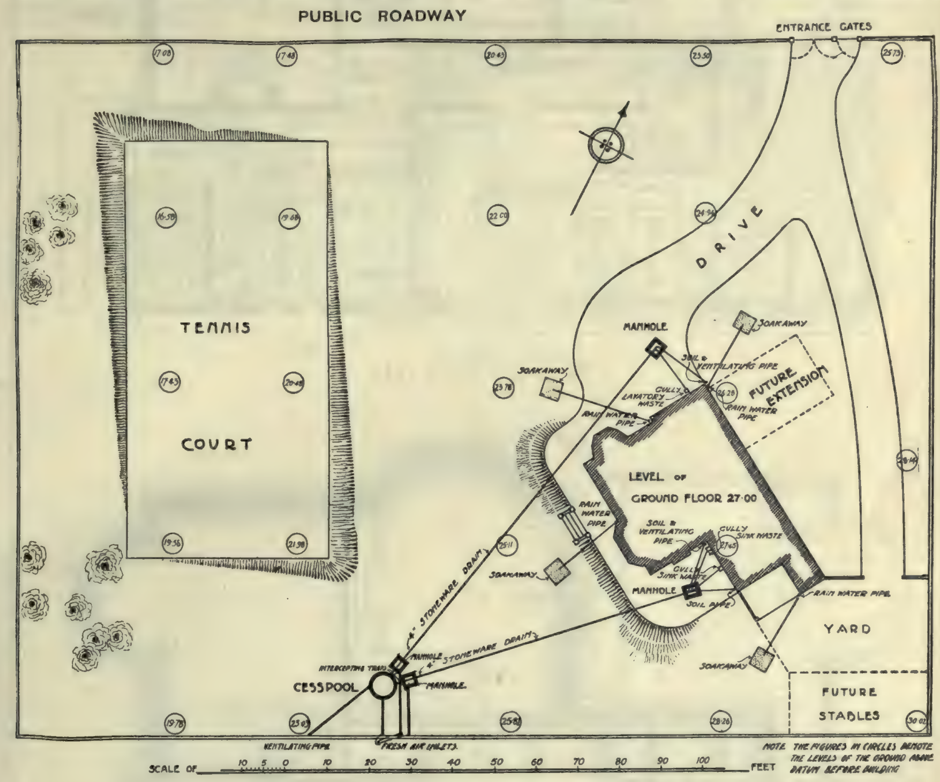
Sections sufficient in number to make the levels and construction clear [**13** and **14**].

The exact number of drawings will depend on the size and complication of the building.

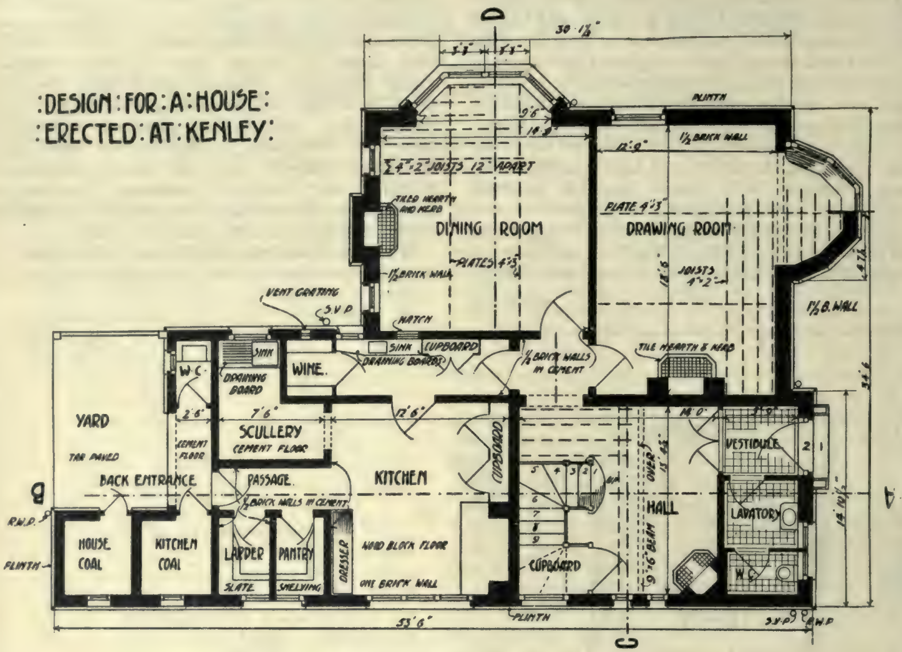
Arrangement of Drawings. The actual size of the sheets will necessarily depend on the extent of the building and the scale used. For very large buildings sheets showing the entire buildings even to ⅛-in. scale are cumbersome to use and awkward to draw, and in such cases a complete block plan to a small scale may be prepared with advantage, the buildings being subdivided into well marked sections, and each treated as a separate building with its complete set of drawings. Where a building is small it may be possible, on the other hand, to arrange more than one drawing on each sheet of paper, and this facilitates reference. When this is done care must be taken to arrange the two drawings in proper relationship one to the other. For example: In the illustration on page 5544. the upper plan [**6**] is placed exactly over the lower plan [**7**] so that the lines of the side walls in the lower plan if carried up will coincide with those in the upper one. Should two elevations or an elevation and section be arranged side by side, care must be taken to see that the horizontal lines correspond in the same way [**10** and **11**]. It is not sufficient to make the drawings accurately to scale, but the leading dimensions should be figured on the plans and sections.

Plans. A plan is a horizontal section taken through the building. The plan of any given floor is presumed to be taken at a level between the floor and the ceiling ; but it is not necessary to assume that the horizontal plane cuts it at one fixed level and that only those features are shown upon the drawings which are cut by such a plane. All important features should be shown on every plan, including the doors and hatches, windows, piers, fireplaces with their hearths, internal windows or borrowed lights, or recesses for any purpose. Also any fittings that are to be fixtures and to be provided by the contractor, such as cupboards of various kinds, fixed tables, sinks, water-closets, lavatory basins, baths, urinals, copper, shelving, etc. In cases where it is necessary to show two features coming one under the other, as, for example, a doorway with a window at a higher level, the lower feature is drawn solidly and the upper feature may be indicated by dotted lines. It is usual to mark on each plan the direction in which the floor joists are to run. This may be done by single or double dotted lines or by lines drawn in brown ink. Any sleeper walls carrying joists in the lowest floor may also be shown, and girders, whether of wood or iron, carrying upper floor joists ; but if of iron they would be indicated in blue ink usually. When the iron work is extensive or complicated it is often shown on a separate set of drawings or tracings used for this purpose. In complicated buildings there are other features that must be shown, but to avoid complication these are often indicated on a separate set of drawings and in different colours. Such features are: systems of passages or trunks used for ventilating complicated buildings; the main runs of pipes for heating buildings, including any coils or radiators; the run of main pipes for taking hot water to various fittings; electric mains, and gas mains.

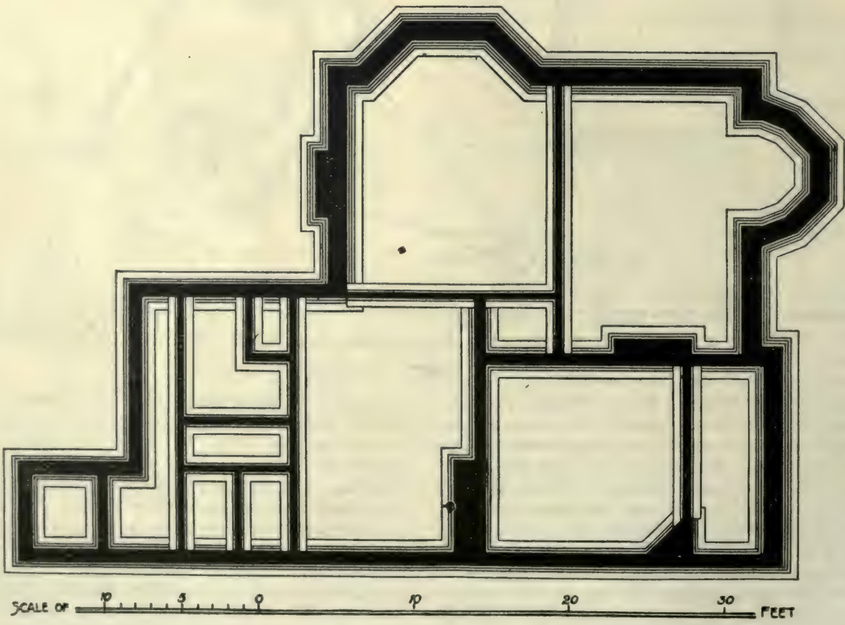
Nomenclature of Plans. The plan of the principal floor, which is usually arranged to correspond in level with the general level of the ground, but to be somewhat above it, is termed the *Ground-floor Plan* ; if there is a floor over the whole or a part of the site below this level, the plan of it is usually termed the *Basement Plan*, but if so arranged that a great part of it is above the ground level it is sometimes called the *Lower Ground-floor Plan*. If there are several floors below the ground floor level they may be described as the *First, Second, or Third Basement Plan*. The plan of the floor next above the ground floor is described as the *First-floor Plan*, and the plans of successive floors are termed *Second-floor Plan*, *Third-floor Plan*, etc., according to the number of storeys



5. SITE PLAN FOR A HOUSE ERECTED AT KENLEY

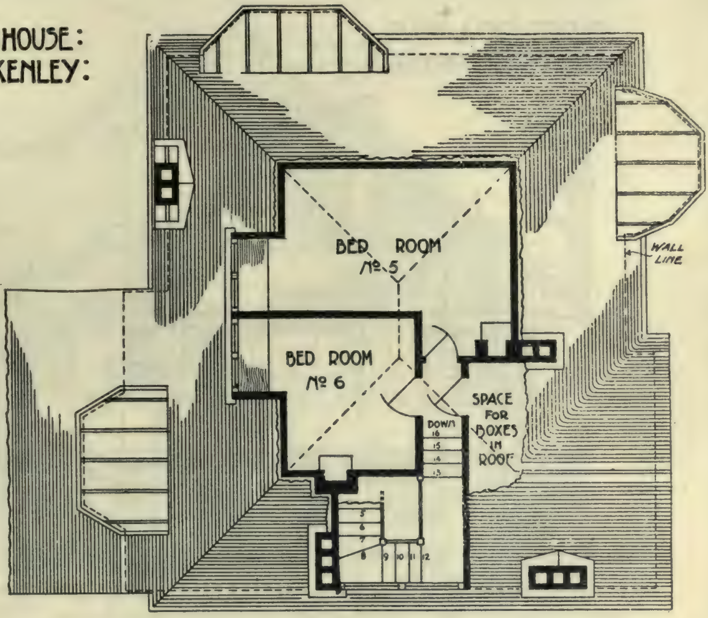


6. GROUND-FLOOR PLAN

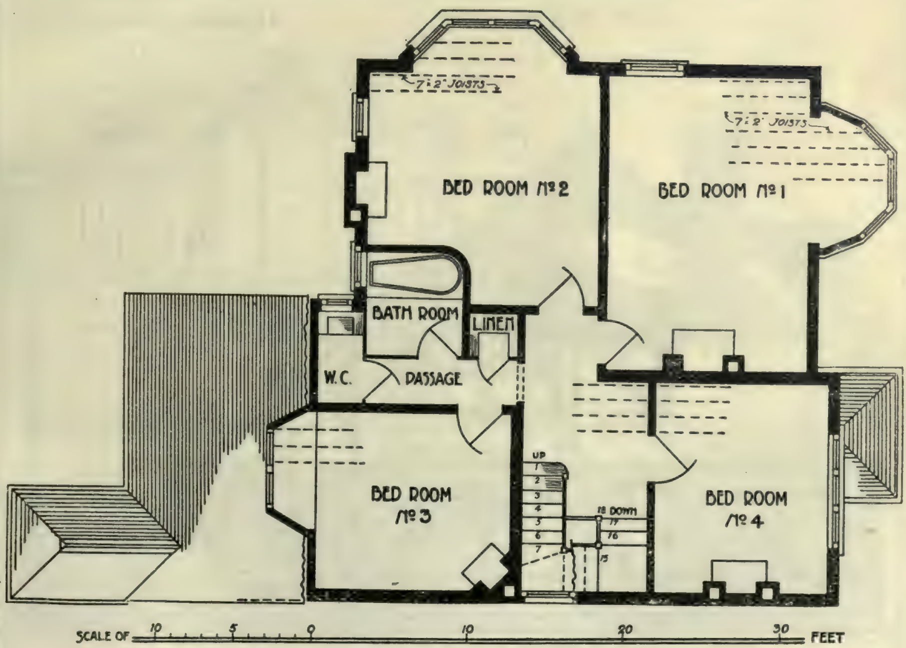


7. FOUNDATION PLAN

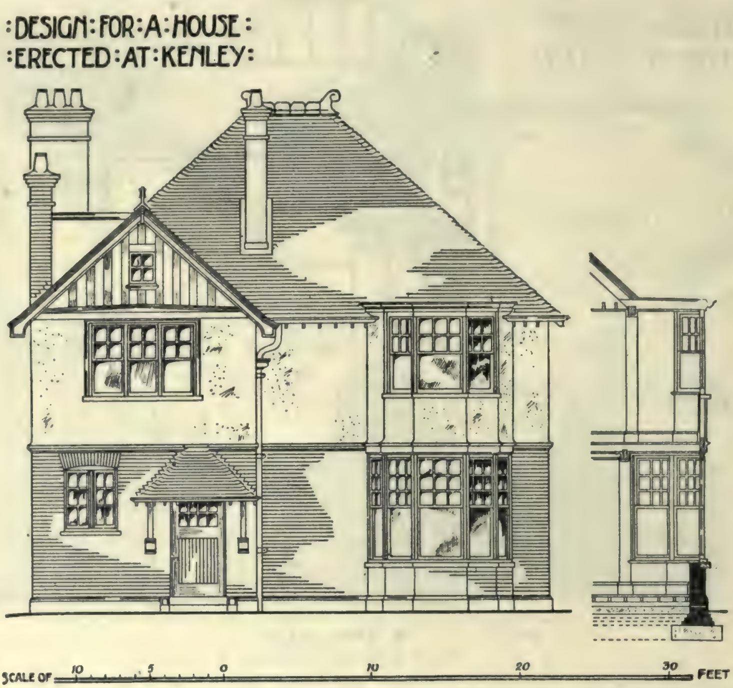
:DESIGN:FOR:A:HOUSE:
:ERECTED:AT:KENLEY:



8. ATTIC PLAN



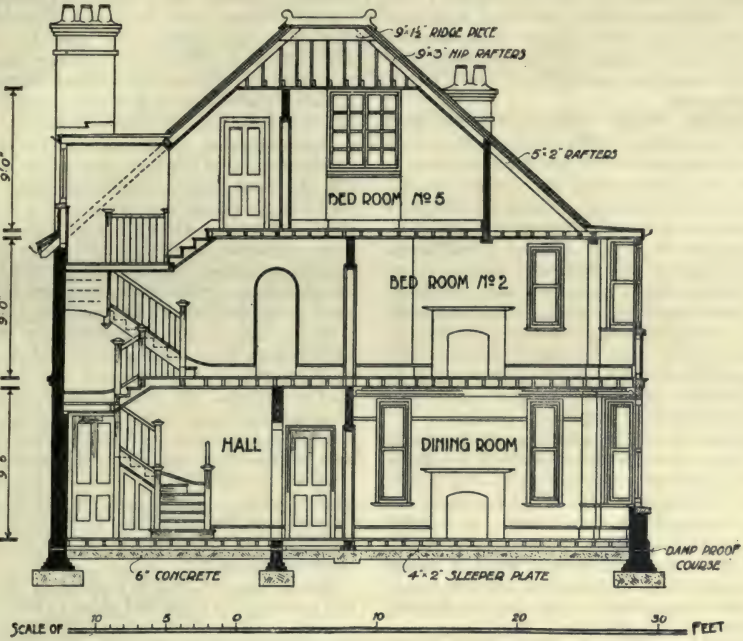
9. FIRST-FLOOR PLAN



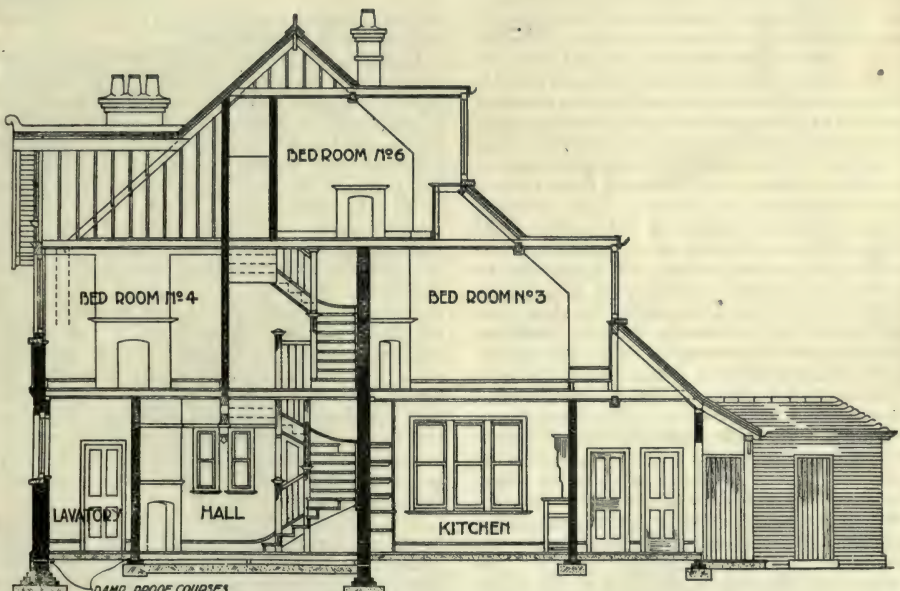
10. WEST ELEVATION

11. SECTION THROUGH BAY

12. SOUTH ELEVATION



13. SECTION OF HOUSE ON LINE C–D IN 6



14. SECTION OF HOUSE ON LINE A–B IN 6

above the level of the ground floor till the level of the eaves of the main roof is reached. The plan of the floor next above this level is termed the *Attic-floor Plan*, and if there is another at a higher level it is termed the *Upper Attic-floor Plan ;* more than two storeys in a roof are not, as a rule, allowed.

Foundation Plan. The foundation plan [7] is taken at a level below that of the lowest floor, and if the external walls have a projecting plinth this will usually be included in the thickness of such walls on this plan. Beyond the thickness of each wall are set out, on either side, the proper number of courses of brickwork for the footings of the wall, and beyond these the lines of the edge of the concrete. Under all ordinary openings in the ground floor the walls are not interrupted, but carried through as continuous walls; the footings and concrete are shown carried round all projections such as chimney hearths, piers, etc.

Basement Plan. Where a basement occurs the plan must show, in addition to the main building, any areas formed outside it to afford light to the basement windows, and any vaults under public footpaths. On all plans, walls are shown as having brick dimensions, no account being taken of the thickness of the plaster on the walls if there is any. The dimensions of rooms as figured on such plans represent the dimension between the unplastered walls, and the finished size of the room is a trifle less.

Ground-floor Plan. The walls on the ground-floor plan [6] are represented above the level of any plinth which may be indicated by a line outside the walls. If the wall is formed of more than one kind of material, this must be indicated by different colours on the plan. This plan at least should be fully dimensioned, and care must be taken, where a series of dimensions are given in different rooms, but extending from side to side or from top to bottom of the plan, that they correspond when added up to the extreme dimensions of the plan. Great care is required in arranging the plans of staircases to see that at all times there is proper head-room—*i.e.*, sufficient height between the upper surface of each step and the next flight or the ceiling immediately over it, to allow of persons passing up and down. This can only be secured by working out the plan and section conjointly. It is usual to number the steps from one floor to the next, and if there is a staircase descending to the basement as well as one ascending to the first floor, a portion of both flights is shown, and broken off by an uneven line; the same thing occurs on each of the upper floors.

The First and Subsequent Floors. The other floors [9] will generally resemble the ground-floor plan in character, but will show the building at a higher stage, and if the walls are reduced in thickness this must appear in the drawings. Any portions of the building that are not carried up will generally have the roof plan shown with the plan of the floor at the corresponding level. In arranging the upper plans care must be taken to see that the walls and divisions come over walls or divisions on the floor below, or when they do not that some adequate means of supporting them is provided. When the building is of a simple character, the attic floor may be combined with the roof plan [8], the lower parts of the roof and the plan of any rooms formed within it being indicated by full lines, while the roof above is indicated by dotted lines.

Elevations. An elevation is a geometrical representation of the true form of a façade [10 and 12]. It is not necessary that every part should lie in the same plane, but every part is represented truly to scale. The plane of the drawing is assumed to be parallel to the main face of the building represented, and any portions of which the plan is in a different plane are represented as if projected on to the picture plane. This may be seen in the representation of the bay windows on illustrations 10 and 12.

The elevation should show the finished level of the ground, all plinths, strings, and other external features, and the levels of all floors should be indicated by dotted lines. It is desirable that all features that will appear when the building is completed, such as soil and rainwater pipes, should be indicated, and the character of the materials to be used should be indicated by the method of lining the walls, assisted by colour.

Sections. A section represents the cutting of the building by a vertical plane [13 and 14]; but, as with a plan, it is not necessary to assume an absolutely rigid position for the plane, so in a section the position of the plane may be varied to some extent at will, so that it shall pass through special features. It must, however, be kept in a plane parallel to the main one, or a distorted section would be produced.

In fixing the position of the line on which any section is to be taken, it should be arranged to show all the most intricate and difficult work, and in particular to indicate all changes of level in floors, and the method of carrying any walls or partitions not resting directly on walls below. All parts of the building actually cut by the plane—the walls, floors, roofs, etc.—will be actually shown in section, while between these will appear in elevation one side or other of the various rooms, corridors, staircases, etc., so intersected, and the line should be in such a position as to make the utmost possible use of all these portions, as well as of the actual sectional parts. It is desirable, for instance, to show important chimney stacks, indicating by dotted lines the manner in which the various flues are gathered over and collected. In addition to complete sections, small sections of special features that would not otherwise appear may be often added to the sheet of sections or to a sheet of elevations as in 11.

It is very necessary to pay particular attention to the arrangement of staircases, and, as already pointed out, to work these in connection with the plans. In indicating staircases on sections it is particularly desirable to show complete flights by the use of dotted lines where the section would not otherwise enable them to be seen.

Continued

DENTISTRY AS A CAREER

The Qualities of a Good Dentist. The Nature of Dental Work. Various Methods of Treatment. The Filling Substances

Continued from page 5432

IF it be possible to form a just appreciation of the prejudices and preconceived ideas of the general public concerning dentistry from the opinions of a dentist's patients, it would seem quite needless to point the way and offer assistance to those who may wish to practise dentistry. For so great appears to be the repugnance which the career of a dentist excites in the lay mind, that one is tempted to believe that there is no one who will care to avail himself of the information and advice tendered in this treatise. It is important, therefore, that, at the outset, the popular conceptions should be carefully considered, so that, if possible, it may be fairly decided how far they are consistent with facts, or to what extent they must be deemed mere fallacies.

The Dignity of the Profession. The practice of dentistry, then, is said to be tedious—"back-aching" is the more graphic description—destructive to the health and eyesight, and disagreeable; it is suggested that it must surely be dreadfully monotonous, lacking both interest and variety, while even the most polite patient occasionally makes it clear that in his opinion a dentist who enjoys his work must be callous and indifferent to the sufferings of his fellow-creatures.

Now, these conceptions of the dentist's work, if they are considered to constitute more than a very partial statement, can be shown to be altogether inadequate and unjust. In the first place, they do not take into account what may be called the dignity of the profession, the importance of the dentist's work to the community, the value of his skilful services to the state and to mankind. Yet this is a very serious omission. On the one hand, the absence of teeth, or the presence of stained or decayed teeth, in the front of the mouth constitutes a peculiarly distressing disfigurement; while, on the other hand, the absence of efficient grinding teeth, or the presence of diseased teeth and gums, at the back of the mouth, constitutes a distinct menace to health. Such conditions are inimical to health, not only because they render impossible the efficient mastication of food, but because they result in the infection or poisoning of whatever food is taken into the alimentary canal.

The Teeth and General Health. In the normal healthy mouth, efficiently armed with teeth, takes place the first, and in some respects the most important, stage of the process of digestion. Here the food is broken up and thoroughly ground to pieces in such a way that the digestive fluids can thoroughly penetrate and soak the mass. In the mouth, too, should take place the thorough mixing of the food with the saliva, which not only constitutes the first stage in the process of efficient digestion, but is also the best preparation of the food for the action of those other digestive fluids of the body which are subsequently to come into contact with it. When effective grinding teeth are absent these important functions are of necessity more or less imperfectly performed, the digestion of the food is more or less faulty, and the nutrition of the patient suffers in consequence. Where, in addition, the teeth are much decayed or foul, and the gums diseased, the patient swallows with every mouthful of food a quantity of disease-forming micro-organisms and their products, while the odour of his breath gives some indication of the extent to which he is poisoning the atmosphere which others are constantly breathing. Such being the case, no one need be surprised at the frequent association of ill-health with bad teeth, for, although a few may for a long time, owing to their great natural powers of resistance, ward off serious ill-health, yet, as decay of the teeth is the commonest disease that flesh is heir to, an immense amount of suffering, sickness, and diminished efficiency for useful work must be directly attributed to disease of the teeth and gums.

Avoidable Tortures. It is significant that in a recent inquiry conducted by a Royal Commission the evidence of the dental surgeon afforded the most direct and positive testimony to the physical degeneration of the people of these islands. It must have been difficult, indeed, to compress the mass of evidence which any experienced dental surgeon would have at his disposal. Generally speaking, the condition of the teeth can only be described as appalling, and this is especially true of the teeth of the lower classes. Very largely owing to utter ignorance concerning the close relationship existing between the condition of the teeth and of the general health, reckless neglect seems to be the rule, and the aid of the dentist is sought only when the tortures of toothache render life unendurable. Yet these results are certainly avoidable, and, even when they already show themselves, it is possible to keep them in check and to effect in most cases a complete cure. It is not necessary to detail here the numerous unhealthy conditions which spring from bad teeth; but it is important to realise how much suffering is the outcome, direct or indirect, of decay of the teeth, and to what extent these conditions yield to careful and skilful treatment at the hands of the dentist,

Here, then, is the dignity of the dentist's work. His calling constitutes him one of the custodians of the health of the community. In this respect his services are second in value only to those of the doctor; and if at times he can only effect a durable repair of the ravages of decay at the cost of some discomfort to his patient, he has

at least the consolation of knowing that he is saving his patient not only from severe pain, but from the risk of serious illness or debility.

The Interest of Dental Work. Again, the popular opinion that the practice of dentistry must be exceptionally monotonous is largely fallacious. It should be remembered that dentistry is essentially a progressive science and a progressive art. Both in the study of the diseased conditions with which he has to deal, and in the practical methods of manipulation with which he combats them, there has been in the past few years an enormous advance, and the dentist who wishes to keep abreast of his day will find that his special branch of surgery will make large demands upon his time and study. It is true also that he is constantly dealing only with teeth ; but his patients fail to recognise that in each day's work probably no two teeth dealt with present quite the same problem for solution. And it would be wrong to argue that the work of a dentist must be lacking in interest as compared with that of a doctor because the dentist has to con[illegible]e his attention to one small part of the body. The same method of reasoning might be applied to a discussion of the comparative interest of the work of a general practitioner and of a specialist in some particular branch of medicine or surgery.

Dentistry, or dental surgery, as it would be better to call it, should be studied and practised as a special branch of surgery, and if this is done no dental surgeon need complain of the lack of variety and interest of his work. To complete the comparison of medicine and dentistry as professions it should be added that, whereas the practice of general medicine is still held to confer a higher social status upon the practitioner, the public recognition of dentistry as a branch of surgery is only a question of time, and is rapidly becoming more general, while the dentist, if his work is tedious, possesses two very real advantages in that his hours of work can be fixed, and that, for the man of average ability, success is more easily to be attained.

The Good Dentist's Qualifications. It should be emphasised that, whereas financial success is not invariably the proof of merit, and still more is not commensurate with the degree of merit, it is probably true that there is little satisfaction in mere financial success. The really successful dentist must have earned not only the reward of his labour but the regard and respect of his patients, as well as the approval of his profession.

What, then, are the qualities which make for success in dentistry, and what ought to be considered disqualifications ?

Fortunately, it may be asserted that, whereas certain natural qualities fit a man to a peculiar degree for the work of a dentist, there are few qualities which cannot be acquired to a degree which ensures average success. Apart altogether from the question of general health, a disproportionately large hand, marked clumsiness of the hands, seriously defective eyesight, and —since the course of education is long and expensive and the examinations of a somewhat high standard—a dull brain, ought to be considered positive disqualifications. To persist in spite of them is to court disaster, involving the waste of valuable time and money.

Practice and Theory. Turning to the positive aspect of the question, it cannot be too strongly emphasised that dentistry is both a science and an art. Without debating at any length whether it partakes more of the nature of a handicraft or a learned profession, it may be confidently stated that the dentist who has not acquired both manual skill and intimate theoretical knowledge of his subject is very imperfectly equipped, and must not expect to be successful. The student who gives his attention to the practice to the entire exclusion of the theory may become within his narrow limits an excellent mechanic as far as mere dexterity is concerned, but he cannot fail to be essentially a rule-of-thumb workman, who will generally do the second best for his patient owing to sheer lack of knowledge of the conditions with which he has to deal and of the means of dealing with them which science places at his disposal. Moreover, to say that dentistry is a science is to affirm that the efficient practice of dentistry demands not only the acquisition of detailed knowledge but, what is equally essential, the habit of thinking scientifically, and of constantly basing deliberate judgment upon a careful study of all the circumstances of every case.

But if it be true that such a dentist is incapable of rendering the highest form of service to his patient, it is at least equally important to bear in mind that a lack of manual skill is an even more serious defect, and that the student who neglects his opportunities of acquiring dexterity in his work makes a still more serious mistake than he who has too little of the scientific spirit in his methods of working.

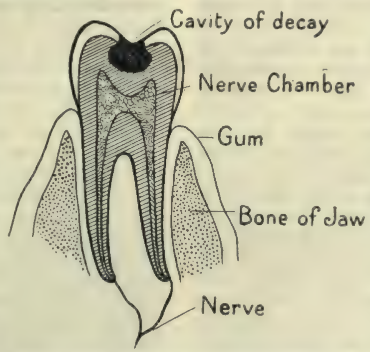
Managing a Patient. These two, then, are essential qualities of the good dentist, without which he certainly does not deserve, and is not likely to attain, success. We have considered already the power of forming right judgments, of deciding what in the circumstances is the best course to pursue in dealing with each case as it presents itself, and it might be thought that, if equipped with these three qualities of knowledge, judgment, and skill, the dentist would be fully capable of dealing with the problems which his work involves, and that success would therefore be assured. That these qualities in themselves are not sufficient is due to the fact that the dentist has to deal not merely with teeth but with individuals. Were it otherwise the dental art would indeed present few difficulties, though it would as certainly be robbed of much of its interest.

But the fact that the dentist has to treat human beings, and not merely a number of teeth, complicates not a little the problems he has to solve. And it does so in two ways. In the tooth he has to deal with an organ of exceptional sensitiveness, which demands not only the gentlest handling of which he is capable and an intimate knowledge of the means of diminishing sensibility, but also a peculiar skill in " managing

a patient." So far is the dentist from being callous to the suffering of others, that a man cannot in any sense of the word be a successful dentist unless he is keenly alive to the pain his manipulation may cause, and unless he strives constantly to minimise it.

The Dentist's Greatest Difficulty. Individuals differ widely in their sensitiveness to pain and discomfort, and in their capacity to endure them for the sake of future comfort and benefit. Some display a fortitude creditable in the highest degree, while others show an impatience and want of control which would be contemptible were they not pitiable. Ostentatious sympathy may destroy for the time the little self-respect which some patients possess, whereas a little firmness may brace a nervous and excitable patient in an extraordinary manner. It need hardly be said that, when he desires to be firm, the dentist must be careful to avoid even the appearance of brutality, for his aim must always be to inspire his patient's confidence, not only in his skill, but equally in his desire to do what is best with the least possible pain. To be successful he must acquire, in addition to technical skill, a knowledge of human nature, the power of rapidly judging temperament, and of accommodating himself to temperament. To reconcile his ambition to do good and permanent work with his desire not to give avoidable pain is, perhaps, the greatest difficulty with which the dentist has to contend.

It may seem superfluous to add that the dentist needs a large fund of patience, and that, if the difficulties of his work or the exasperating conduct of his patient have exhausted it, he must assume a virtue which he no longer possesses. A word should be added on the desirability of acquiring the habit of absolute fairness, almost of generosity, in all that is said to patients with reference to work done by other practitioners. This quality, like that of conscientiousness in working, the best kind of patient will always learn to admire and respect, and both will earn in time their own reward.



1. SECTION OF TOOTH, SHOWING NERVE CHAMBER, CANALS AND CAVITY OF DECAY

A Day in the Life of a Dentist. Two other matters call for consideration. One is the quality of invariable courtesy; the other that of scrupulous cleanliness. They do not need to be enforced by any argument. They are absolutely essential, and no greater mistake can be made than to suppose that they can be assumed at will for the occasion. They must be part and parcel of the man.

There is the greatest practical need for what has been said of the popular ignorance of the realities of the dentist's work. It is important that no young man should take up the work of preparing himself for practice under an entirely false impression, and it may be helpful to give some idea of a typical day's work in a dental surgery.

The first patient may be waiting for the dentist when he arrives in the morning; and it transpires that he has spent a night of such agony as only those familiar with toothache at its worst can realise. With little warning, severe pain may have come on soon after the patient retired on the previous night, and raged almost without cessation. None of the simple domestic remedies have been, in his case, at any rate, of any avail; and, in spite of great repugnance, the dentist's assistance is sought at the first opportunity, with the determination to "have it out."

The First Problem of the Day. Here, then, is the first problem of the day. The dentist has to form an opinion upon the cause of the pain, and to decide upon the best method of dealing with it. Without entering deeply into technical details, it may be said that pain of this kind is probably due to one or other of two causes. Every reader who has spent much time in the dentist's chair has heard of what is called "the nerve." This bundle of blood-vessels and nerves, which travels through a minute hole at the end of the root of a tooth, and thence through a tiny canal which runs through the centre of the root from end to end, finally spreads out to form a clump in the centre of the tooth itself [1]. When decay attacks a tooth there may be little or no pain until the hollowing-out has gone so far that a cavity is formed nearly as deep as this clump of blood-vessels and nerves. Even at this stage there may be no pain unless the nerve is injured by an instrument or some hard particle of food bitten into it. More often, however, a nerve which has in this way been exposed by the hollowing out of decay will become inflamed and extremely painful, and, if left to itself, will most likely inflict intense suffering for days, when it may cease in a mysterious way to hurt any longer. In such a case the nerve is said to have died, and is, in fact, no longer a part of the living body. It is like a limb which has been amputated, or a finger which has been frost-bitten. In other cases the inflamed nerve gradually ceases to be painful, and there may be relief for a few days, weeks, or months, and then, perhaps, another severe attack, during which the nerve finally dies.

Danger of Neglecting a Dead Nerve. Unfortunately, the pain which a nerve is capable of causing is not limited to the time when it is alive. The presence of that bundle of dead tissue in the tooth and in the root or roots of the tooth, constitutes a real danger. This dead matter, if it be attacked by micro-organisms or microbes—which are exceedingly

common in mouths that are neglected—will decompose; and, unless the gases and poisonous juices which result from decomposition can escape through the cavity which decay has made, they will pass through the minute hole at the end of the root and cause an inflammation of the bone and soft tissues of the jaw. This inflammation is the beginning of an abscess, or collection of matter, which ends by opening upon the surface either of the gum or of the skin of the face, chin, or neck. This, then, is the second cause of severe toothache, and the first work of the dentist is to determine which condition is responsible in any particular case.

The Folly of Indiscriminate Extraction. Having determined this, partly by asking questions calculated to elucidate the circumstances of the case, and partly by a careful examination of the tooth and its surroundings, the dentist has next to decide how best to relieve the pain. An inexperienced patient, having suffered acutely from such a tooth, will no doubt strongly urge that the offender should be removed, and, unless reasons can be urged against this, the suggestion will certainly be followed, since it is obviously the quickest and simplest method of giving complete relief. But the modern dental surgeon, and with him at least a section of the public, has come to realise that the extraction of teeth, though in most cases a beautifully simple way of getting rid of pain, is an operation not lightly to be undertaken—an operation, indeed, which should be regarded only as a regrettable necessity in certain cases. When a tooth is still capable of rendering useful service, every attempt should be made to preserve it. A wise patient will prefer to endure some discomfort rather than sacrifice a useful tooth to the forceps, and the conscientious dentist will do his utmost to dissuade a patient from extraction if the tooth can be permanently and usefully preserved without making an unjustifiable demand on the patient's endurance.

The Method of Treatment. Naturally, the method of treatment will vary with the cause of the pain. In a case of exposed or inflamed nerve, the dentist will remove some of the decayed tooth-substance which more or less fills the cavity, and, having located the spot at which decay has attacked the nerve, will apply to it a small quantity of one or other of the various nerve-destroying substances at his command. Most of these preparations contain arsenious acid, which has the peculiar power of destroying the vitality of the nerve, combined with other drugs which are added for the purpose of relieving the pain temporarily, until the arsenious acid has had time to complete its work. The nerve-destroying preparation is then sealed in the cavity with soft gutta-percha or some other temporary stopping material, and the patient dismissed, an appointment being made for another visit.

If, on the other hand, the case be one of incipient abscess, the decayed substance is more freely removed, and the cavity enlarged until the dead nerve material is accessible. As much of this as can be removed without much grinding and cutting is then cleared away, and a little pad of cotton-wool soaked in carbolic acid or some similar antiseptic is placed in the cavity previously occupied by the nerve. This is then sealed in as before, and an appointment made for another visit.

It will be understood that in dealing with either of these conditions, especially with an exposed nerve, the utmost delicacy of handling is demanded. The tooth and its surroundings are acutely sensitive, and it should be the dentist's aim to manipulate them as little as may be consistent with relieving pain. Such a patient, having probably passed a sleepless night, and being inclined, perhaps, towards extraction, deserves to be treated with every consideration and to be saved from all unnecessary pain.

Filling the Tooth. Let us suppose that the next patient is one who a week ago was in much the same straits as the first patient found himself in this morning. The nerve-destroying material was applied, and relief obtained. There may have been for a short time during the succeeding night or day a return of pain of varying intensity, but the tooth is quite comfortable again now, and the next step towards the permanent saving of it may be taken.

This is the filling of the tooth. The operation consists of the removal of the inflamed nerve, which is now dead. and subject, therefore, to decomposition. This is performed by means of tiny barbed steel bristles, which are inserted into the nerve canal and withdrawn when the sharp barbs have caught the nerve tissue firmly, drawing it out of the canal. The complete removal of the dead tissue having been performed by means of these bristles and by fine drills rotated in the foot-engine with which most people are acquainted, the tiny canal is filled with little lengths of gutta-percha or some other filling material, and steps are taken to fill the cavity which decay has made, and which may have been enlarged by the dentist in order to enable him to obtain access to the canal or canals of the tooth. This, then, is the place to refer to the difficult problem of the choice of the most suitable filling materials.

The Ideal Filling Substance. Anyone who considers the matter carefully will perceive that a substance which is to serve the purpose of a tooth-filling should have certain qualities. It should be hard enough to withstand the force of biting and chewing; its appearance should resemble that of the tooth in which it is inserted, so that it cannot be detected; it should form an insoluble, watertight, non-poisonous plug which is not irritating to the delicately sensitive nerve close to which it is placed. It should not conduct heat or cold readily; it should be naturally adhesive to the sides of the cavity; and it should be capable of being inserted so quickly and painlessly as not to be disagreeable to the patient, and so easily that failure to fill the tooth well and permanently is almost out of the question. Unfortunately, although many years of research have been devoted to the attempt to discover a substance

combining all these desirable qualities, there is nothing known which can be called an ideal filling material. Many of the substances at the dentist's command possess some of the qualities desired, and in a few cases almost all the qualities needed are found combined in one material. The dentist has, therefore, the task of deciding in each particular case which qualities are least essential and which seem most desirable, and of making his choice in accordance with the judgment he has formed.

Common Filling Materials. The substances in common use as fillings may be classified.

METALS. Pure gold in various forms and pure tin are examples.

CEMENT. Formed by mixing certain acids, as phosphoric acid, or the acid salt zinc chloride. with certain salts such as zinc and magnesium oxides, the compound becoming hard in the course of a few minutes.

AMALGAM. The result of combining mercury with certain metals such as gold, silver, copper, zinc, or tin, the compound becoming hard within a period which varies from a few minutes to several hours.

GUTTA-PERCHA. Used in various forms.

PORCELAIN. The mineral which is the result of fusing compounds of silica by great heat.

It is impossible within our limits, and unnecessary for our purpose, to enter at length into a discussion of the properties of these substances, which are more fully treated in CHEMISTRY. The subject is an intricate one, involving much technical knowledge, which it should be the aim of the student to acquire. It will be seen, however, that the choice of the most suitable of them for each individual case gives scope for the exercise of mature judgment, and that the skill requisite for the manipulation of so many different substances to their best advantage is of a high order. The majority of them, possessing little adhesiveness, require that the cavity into which they are to be inserted should be specially prepared by cutting grooves and dovetailed holes, in order to render it retentive in form.

Removing the Dead Nerve. The next patient may be one for whom the growth of abscess has been cut short in the manner described when the requirements of the first patient were being discussed. Here, again, the first object which the dentist sets before himself must be the complete removal of the dead, and, in this case, decomposing nerve-tissue. The latter will be in a more or less fluid condition, and great care has to be exercised in its removal to avoid driving any of the poisonous material through the aperture at the end of the root into the tissues surrounding the tooth, where it may, as we have seen, cause serious inflammation or abscess. The canals having been thoroughly cleansed and filled, the problem again resolves itself into one of the choice and insertion of a filling material.

Following this there may be a succession of patients presenting teeth in which the process of decay has not advanced so far, and the dentist may decide that the tooth can be safely filled without first destroying the nerve. The advantage of this procedure consists in the fact that the full nutrition of the tooth is unimpaired by the loss of some of the blood-vessels which supply it, the life of the tooth being consequently prolonged. The risk of the procedure is that a filling material, if placed too near the live nerve, may irritate it, and thus cause inflammation and severe pain.

During the day's work, also, there will probably be several visits from patients requiring some slight adjustment of the artificial teeth they are wearing, which, owing to some change in the mouth, are causing discomfort.

Dental Work Among Children. The dentist may also be consulted with reference to children in whose mouth the teeth, as they appear through the gums, are taking up unusual positions, causing disfigurement or pain, and he will have to deal with these either by extraction or by adjusting to the mouth various forms of appliances which correct the irregularity by pressure upon the offending tooth, which guides it to its proper place.

Finally, there is a class of patient who present an entirely different problem. These people have in many cases been recommended by a doctor to seek the aid of a dentist in curing the diseased conditions which are largely the result of deficient or diseased teeth. By far the commonest of these conditions is dyspepsia or indigestion. Such a patient's mouth may present an appalling picture of the ravages of decay. Many of the teeth may be so extensively decayed that nothing remains of the crown. Other teeth are coated with a hard substance called tartar, while many spaces indicate how often a tooth has been sacrificed to the forceps for the relief of pain.

The Dentist as Doctor. For such a patient the dentist may have to perform a variety of operations. Some diseased and useless stumps may need extracting, during which the patient may be rendered unconscious by the administration of anæsthetics ; for some it may be possible to construct and attach an entire tooth-crown of gold ; the tartar has to be removed, and the gums restored to health ; cavities in teeth which it is decided to preserve must be filled, while it is often necessary to supply the place of teeth that have been lost by artificial ones made of porcelain and mounted upon plates of gold or some other substance carefully adapted to the jaws.

Such, then, is a short survey of a day's work in a dental surgery, and at the cost of repetition it may be added that the mechanical and surgical problems alluded to are generally complicated by some degree of sensitiveness, ignorance, prejudice, or even obstinacy on the part of the patient. It is needless to say, perhaps, that outside the actual work of the surgery the conduct of a busy dental practice involves the writing or superintendence of a considerable correspondence and book-keeping.

Continued

Group 15
HISTORY
39
Continued from page 5397

A NEW DYNASTY FOR ENGLAND

The Work of Sir Robert Walpole. Wolfe's Capture of Quebec. Canada and India. The Gordon Riots. The Ministry of William Pitt

By JUSTIN McCARTHY

THERE was no direct heir to the throne when Anne died, and the supporters of the Stuarts and those of the House of Hanover hoped to snatch the crown. The House of Guelf, to which George the Elector belonged, traced its descent to the days of Charlemagne. One of its members had married a daughter of Henry II., and thus founded the Brunswick family.

George the Elector was born at Hanover on March 28th, 1660. He was the eldest son of Ernest Augustus of Hanover and of the Electress Sophia, daughter of James I., and was thus connected with the line of English sovereigns. On Anne's death he was proclaimed King of Great Britain and Ireland. He had been Elector of Hanover since 1698, and had fought in the campaigns of Marlborough. In 1682 he had married his cousin, the Princess Dorothea of Zell. The marriage was unhappy, and ended in a divorce.

Sir Robert Walpole. George I., on his accession, immediately nominated an entire Whig Ministry, with Charles Townshend as Prime Minister. He was, however, soon succeeded by the famous Sir Robert Walpole, who, during the reign of George I., practically ruled the country. He had held office in Queen Anne's reign, but was found guilty of peculation, expelled from the House, and imprisoned in the Tower. In 1715 he became First Lord of the Treasury and Chancellor of the Exchequer. He resigned two years later, but on the death of Stanhope he again filled both offices, which he held until his resignation in 1742, when he was created Earl of Orford.

He was a great financier as well as a great statesman, and it was his financial genius which prevented the most serious consequences from following the failure of the South Sea Company—the "South Sea Bubble."

The story of the Stuart risings in the reigns of George I. and George II. has already been told. In 1723 Bolingbroke returned to England, joined the opposition to Walpole, and contributed to the "Craftsman," a political publication of that time started by Bolingbroke and Pulteney. A brilliant politician of that day was Carteret, afterwards Earl of Granville, another bitter opponent of Walpole.

George II. George II., who succeeded his father as Elector of Hanover and King of Great Britain and Ireland in 1727, was born on November 10th, 1683, and was declared Prince of Wales in 1714. He took a more active part in the government than his father before him had done, but during the early part of his reign Sir Robert Walpole was still the ruling power. George II. was not a man of any great qualities, and his private life was, like his father's, immoral, although he was much influenced by his wife.

England was at peace with other countries until the death of Walpole in 1745. During that time many treaties were made, one with Spain in 1729, known as the Treaty of Seville, which was confirmed two years later by the Second Treaty of Vienna. In the same year Townshend retired because Walpole compelled him to reject the Pension Bill.

The Tax on Wine and Tobacco. Walpole wished to follow his tax on salt by one on wine and tobacco, but this was so unpopular that he had to abandon it. The Definite Peace of Vienna was signed in 1738. Walpole retained his majority, and Bolingbroke went to France, where he remained until 1742. In the following year occurred the famous Porteous riots in Edinburgh, caused by the hanging of a smuggler called Wilson. Captain Porteous, of the City Guard, commanded his soldiers to fire on the mob who had rioted, and some of the people were killed. Porteous was condemned to death, but on being respited by the Government was seized by the rioters and hanged. The Lord Provost was dismissed, and the city had to pay the widow of Porteous £1,500.

In 1737 the Prince of Wales quarrelled with the King about his jointure, in which the King's party were successful in Parliament. Two years later Walpole was compelled to declare war against Spain, but the expeditions which were sent were not successful. In 1742 the Government came in with such a small majority that Walpole resigned office, and in the next year Henry Pelham became Prime Minister. The question of the Austrian Succession now came up again, and a large army of English and Hanoverians was sent to the Netherlands. George II. took part in the war, and commanded the English and Hanoverian army at the Battle of Dettingen in 1749, where he greatly distinguished himself. No English king has since taken part in a battle. Two years later the King's second son, the Duke of Cumberland, fought in the Battle of Fontenoy, in which the French, under Marshal Saxe, were victorious. In this war the Irish Brigade, composed mainly of Irish exiles, fought on the side of the French. The Treaty of Aix-la-Chapelle ended the war in the Netherlands in 1748.

The Seven Years War. In the meantime Pelham had resigned and returned to office. In 1751 the Reform of the Calendar was introduced, and in 1753 Hardwicke's Marriage Act. Pelham died in 1754, and Newcastle became Prime Minister. The Seven Years War began in 1756. Minorca was captured by the French, and Newcastle resigned. In the same year a Coalition Ministry was formed, with Pitt as Prime Minister. The King had for a long time refused to receive Pitt as a Minister, but had at length

been compelled to give way, as it was impossible to form a Government without him. Pitt thus became Secretary of State and Leader of the Commons.

The Seven Years War went on with varying success. The Duke of Cumberland was defeated at Kloster-Seven, and compelled by the French to capitulate. In 1758 Ferdinand of Brunswick succeeded him, and in the following year he won a great victory at Minden. In September of the same year Admiral Boscawen defeated the French at Lagos. One of the great events of this year was Wolfe's capture of Quebec. This victory laid the foundation of one of England's finest Colonies. The leaders on both sides were killed in this struggle—the Marquis of Montcalm in the hour of defeat, and Wolfe in the hour of victory. In November Hawke defeated Conflans off Quiberon.

Clive, the Hero of Plassey. In the meantime the great English soldier, Robert Clive, who has been called the real founder of the Anglo-Indian Empire, won the famous victory of Plassey, and in 1759 the siege of Madras was raised, and Coote took Wandewash.

George II. died on October 25th, 1760—the year following these famous victories.

George III., his grandson, succeeded as King of Great Britain and Ireland and Elector of Hanover. He was born in London on June 4th, 1738, his father, Frederick, Prince of Wales, having died before George II. In 1761 George III. married the Princess Charlotte of Mecklenburg-Strelitz. George III.'s reign was one of the longest in English history. In it occurred some of the greatest events of all time, and in it, too, lived some of the greatest of English statesmen. George III. was very different from either of his predecessors. He had no intention of leaving the country in the hands of his Ministers; he wished to rule himself. The Minister who had most influence with the King was Lord Bute, who was, however, extremely unpopular with the English people. The King was violently opposed to the Whigs, and in 1761 the "King's Friends," as they were called, succeeded in driving Pitt—afterwards the famous Earl of Chatham—from power.

The Prosecution of Wilkes. The Peace of Paris, in 1763, reversed the policy of Pitt. George Grenville was Prime Minister in 1763, and was succeeded in 1766 by Rockingham. Pitt, now Earl of Chatham, would have been willing to become the head of the Government but for an illness which made it impossible, and the Administration was continued by the Duke of Grafton. The prosecution of John Wilkes for the famous No. 45 of the "North Briton," the paper in which he criticised the King's Speech, made him the most popular man in England, and his name has ever since been associated with liberty. Wilkes was at this time Member for Aylesbury, but as he did not obey the order of the House to attend in his place he was expelled in his absence. In 1768 he stood for Parliament for the City of London, but, being defeated, he at once became candidate for Middlesex, and was elected by an overwhelming majority. Wilkes was sentenced to a fine of £1,000 and imprisonment for twenty-two months, and a new writ was issued for Middlesex; but Wilkes was again returned. Whenever the law declared him disqualified to sit in Parliament the electors of Middlesex again elected him, and when at last, in 1774, Parliament was dissolved, and Wilkes was again returned, the contest was not re-opened, and he was allowed to take his seat.

The Gordon Riots. Lord North became Prime Minister in 1770, and remained so for twelve years, during which the country was in reality ruled by the King, of whom North was merely the instrument. These years were disastrous for England. The policy of coercion used by the King's wish towards the American Colonies led to the American Revolution, the story of which is told later. In 1778 Lord North wished to resign in favour of Chatham, but this the King refused to allow, and the death of the "Great Commoner" in the following year left the King free to pursue his own policy with regard to America, in spite of the remonstrances of North and the resignation of several of his colleagues. The Gordon Riots began in 1779 by a meeting in St. George's Fields of a body of 50,000 people to present a petition for the repeal of the Catholic Relief Act. The mob, encouraged by Lord George Gordon, forced their way into the House of Commons. The House adjourned and the mob dispersed, but committed all manner of acts of violence. Gordon now thought his followers were going too far, and tried to restrain them, but it was too late. The Commons met after the adjournment on June 6th, and decided to consider the petitions, but the same night the mob broke open Newgate and released the prisoners. The King behaved with courage and resolution, and the military were immediately employed to put down the riot.

Fox's East India Bill. Notwithstanding the King's dislike of the Whigs, there was now a Whig Ministry, and in 1783 the Coalition Ministry of Charles James Fox and Lord North came in, resolved to break the Royal authority. The King determined to appeal to the country against the Government, and by unconstitutional means procured the rejection of Fox's East India Bill. Parliament was dissolved, and the elections resulted in a victory for the King over the Whigs. William Pitt, the son of Chatham, formed a Government in 1783, and under his administration England was powerful and prosperous, and the popularity the King gained in consequence was entirely due to the genius of his great Prime Minister. The King's mind became affected in 1789, but he soon recovered. The public rejoicings at this event were, perhaps, due more to distrust of the Prince of Wales than to any enthusiasm for the King; and the outburst of the great revolution in France had the effect of inducing many of the moneyed classes to support the Throne. But the lower classes suffered much from repression and injustice, and were consequently glad to welcome the new democratic doctrines which were gradually spreading over Europe.

Continued

Group 19
PRINTING
5
Continued from page 5460

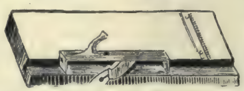
A NEWSPAPER IN METAL

The Foundry. Stereotyping. The Papier Mâché Process. Quick News Methods. The Autoplate. Electrotyping. The Dalziel Process. Finishing Blocks

By W. S. MURPHY

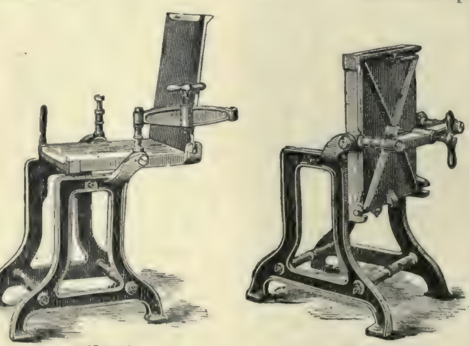
THE process of printing wears out type, every impression flattening the surface by an imperceptible yet definite degree. Type is costly, and the printer naturally seeks out means to lessen the wear and tear on it. Other considerations prompt the idea. For instance, many books run to 600 pages, and no printer could allow all that amount of type to stand in pages. Of course, the obvious remedy is to print off the first formes, distribute the type, and use it for the following portion of the book. But if another edition of the book is called for, it all requires to be set anew. By taking a mould off the pages, from which any number of reproductions can be cast, all that expense and trouble may be obviated.

The Paper Process. The paper process may be resolved into four parts: (1) the composition of the "flong"; (2) forming the matrix; (3) casting the plate; (4) finishing the plate.



28. FLAT SHOOTING BOARD AND PLANE

Typefounders have so simplified the furnishing of the stereotype foundry that a complete equipment could be carried in a wheelbarrow; but as concentration, in this case, produces complexity, we will go into a large modern foundry, where everything can be seen on an expanded scale. First there is the *metal-pot*, in which has been melted an alloy of lead, tin, and antimony, heated by a fire or gas; next stand the *hot plate*, a table with an iron top, hollow, for heating from the inside by steam or gas or coal furnace fumes, and over the end of the table the *matrix-press*, looking in every respect like a gigantic letter-copying press. Firmly based on its thick legs stands the large iron-topped *imposing table* [32]; near it is the *chase-rack*, holding a number of chases, ranging in size from large quarto to little things capable of holding a small card. Over a bit, out of the way of the founding operations, we see the machine department, with circular saw [31], cutting lathe, bevelling tool, and shaving knife. On the benches and tables lie brushes, shears, and various small implements. In small offices, the hand shooting-board and plane, shown in 28, is used. Scarcely observable, but most important, sits the *paste-pot*, with its brush, and on the bench near lies the store of tissue and blotting papers, without which the paper process would be impossible.



(Open) (Closed)

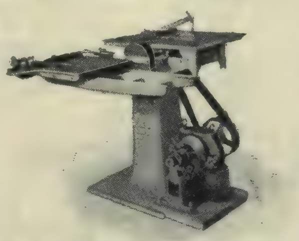
29. CASTING BOX

30. BEATING BRUSH

Making the Matrix. This array of tools and appliances will become intelligible as we proceed. The forme is brought in from the composing-room. If it is a large forme, the stereotyper usually breaks it up into smaller sections, the unit preferred being two pages. Damping the type to make the letters cling, the workman unlocks the forme, sets the clumps round the first section, and locks it up. He now prepares the *flong*. On a sheet of thick blotting-paper a thin layer of paste is brushed, and upon it a sheet of tissue-paper is evenly laid. Another application of paste, and another sheet of tissue, and then another two sheets pasted as before, compose the flong. Oiling the surface of the type, the workman lays his flong over it. This done, he puts a linen sheet over the flong, and, taking a long brush [30], begins to beat the flong into the type. The linen cover protects the soft, pasty composition, while conducting the blows of the brush bristles. Beating the flong demands dexterity, supple play of wrist, and fine judgment. A few unsteady or irregular strokes ruin the whole thing. When the flong has been sufficiently beaten, a sheet of stout wrapping-paper should be pasted on the back to strengthen it, and then the forme, with the flong on it, is carefully removed to the hot plate. Protected by a few layers of blanket, the forme is run under the press, which is screwed tightly down on it. In a few moments the press is unscrewed, the forme drawn out, and the matrix cautiously skinned off the face. Having been tightened, the forme is sent back. Pasting a flap of brown paper on the bottom of the matrix, the workman stretches it out on the hot plate under weights at each corner to dry.

Casting the Stereotype Plate. When the matrix has been thoroughly baked, it is trimmed and made ready for the casting-box. The *casting-box* [29] is merely two thick iron

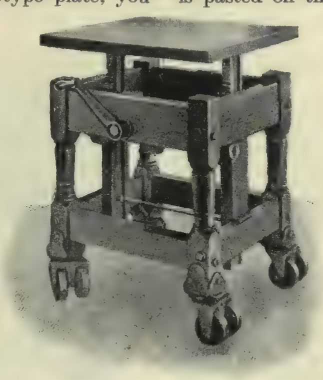
plates, loosely hinged together at one end, fitted with closing clamp at the other, and mounted on a stand with swivels and springs that hold it in either a horizontal or vertical position. For the reception of the matrix the casting-box is put in the horizontal position, and the upper plate lifted back. On the level plate the baked matrix is laid, and round its three sides flat bars of steel, an inch broad and $\frac{1}{8}$ in. thick, are set. The upper plate is brought down, and a mould formed. Firmly clamped, the casting-box is turned to the vertical position. The flap we saw fixed to the matrix now lies over the mouth of the casting-box, and forms a feeding-apron for the metal. Having filled his ladle at the melting-pot, the caster pours the metal into the mould. Lead settles and cools quickly. In a minute the mould is opened, and a bright new plate comes out.



31. CIRCULAR SAW AND BEVELLING MACHINE (R. Hoe & Co.)

Trimming and Squaring the Plate. When the stereotype plate leaves the mould it is not ready for printing. A quantity of superfluous metal hangs about it, and other finishing touches are needed. Clear off the tags and rims with the circular saw [31], a toothed disc of steel set on a spindle within an iron table and driven by power. Our plate is too thick and the back too rough. For remedying these defects we have the planing machine or shooting-board and plane [28]. Rasp the top and bottom of the plate with a file to the depth you see necessary as a guide to the tool. Otherwise it may shave off too much. When the knife has passed over the plate it is of the right thickness and as smooth as glass.

If you look at an old stereotype plate, you will see that the edges are smooth and slanted or bevelled, whereas a plate fresh from the saw has a rough and straight edge. Besides, the sawn plate is seldom exactly square. The inventors have foreseen the need, and provided squaring and bevelling machines in numbers. The best and simplest consists of a movable iron table, fitted with screws and gauges for fixing the plate, set against a vertical spindle, capable of being driven at enormous speed and armed with a triple knife. Protect the face of the plate from the iron table by a pad or blanket, set it true in position, and let it move slowly along the whirling knives. In a few moments a finished plate results.



32. IMPOSING AND BEATING TABLE

Quick News Methods. Book-printing is rather a leisurely business. A day or two lost in the production of a book matters very little. With the newspaper the case is altogether different; it must be out every morning to the minute. Four large sheets, containing as many words as an ordinary novel, have to be set, stereotyped, and nearly a million copies of them printed in the space of a few hours.

The storm centre of this cyclone of labour is the foundry. As every page comes in on the trolley table there is a sudden rush of busy men, and the foundry becomes the scene of arduous labour.

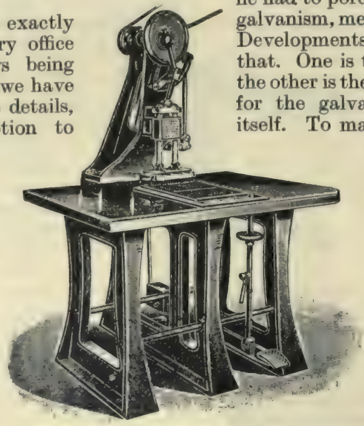
Yet the stereotyper has not been caught unawares; he has been ready for the rush. Sheets of flong have been prepared and cut to page size, and lie waiting between damp cloths. The huge metal-pot is at the proper heat; the hot press awaits the forme, and the casting-box stands in position. It is round, like the segment of a circle, and this segment fits the circumference of each cylinder of the great rotary printing machines which will shortly be rolling off the newspapers at the rate of 90,000 per hour.

Working Against Time. The advertisement pages come in early, and they are cast in a more deliberate way than the late news pages. But the appliances and methods are the same. The forme comes in on the trolley, or table, and the workmen promptly slide it on to the imposing stone, or table. A swift brush with oil makes the type surface glisten, and then the flong hides it from view. Two men rapidly beat the flong into the type with brushes. Or, if the equipment is up-to-date, a flong-beating machine [33] performs the operation even more quickly. A thick sheet of paper is pasted on the back of the flong. Further protected by a flannel sheet, the forme is run under the roller geared at the end of the table, which deepens the impression on the flong [34]. Pressed and dried in the way formerly described, the matrix passes into the circular casting-box, and is cast. The finishing tools in the newspaper stereotyping foundry are automatic, as a rule. The *trimming saddle* is a curved block, equipped with cutting tools at end and side. On this the plate is fixed, and the knives quickly shear off the tags and margins on one end and side. To turn the plate round takes no time, and in another moment the whole plate is trimmed. But the back of the plate may be rough and uneven, and our flat planer is of no use for that curved thing. A planer has been devised to meet the need. This is a lathe with circular bed and circling knife. Laid face downward in the circular bed, the back of the plate

yields its irregularities to the cutting tool, which rapidly moves in the same circle as the surface of the machine cylinder. The first stereotype plate can be produced complete in ten minutes, and subsequent plates in a much shorter period.

No newspaper office is exactly like another, and in every office improvements are always being devised. For that reason we have purposely avoided minute details, and confined our description to the general features of the process.

The Autoplate. Rapid as the process of stereotyping for newspapers has become, the demand is for processes more rapid still. Short though the pause is between the locking-up of the formes and the coming of the stereo plates down the lift, it occurs just in the period when seconds are precious. The obvious remedy was a stereotyping machine, but it was easier to point to the way out than to invent the machine. In course of time, however, the desired time-saver appeared in the shape of the machine known as the "Autoplate" [35]. This machine consists of a casting mechanism and a series of finishing mechanisms which automatically co-operate in one machine to make the casts and finish them. It runs at the rate of between three and four plates a minute, and turns out a better quality of printing plate—with a harder and finer surface—than it is possible to make by hand. The improved quality of the plates is more particularly evidenced in pages containing illustrated matter, by reason of their being cast under great pressure.



33. BRUSH STEREO-MATRIX MOULDING MACHINE
(Whitehead, Porteous & Co.)

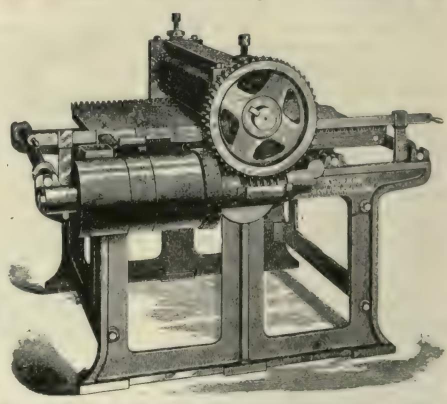
In the casting mechanism, at one end of the machine is placed the matrix. The operator, by the turn of a lever, starts the machine casting, and it proceeds automatically until the desired number of plates has been made and sent to the finishing devices. Then the matrix is removed, and another inserted, an act which requires but an instant of time.

During the operation of the machine the matrix is cared for automatically; and having been once inserted and secured, it requires no further attention until the full quota of plates is cast. The mechanism is so constructed that the matrix is manipulated with the utmost gentleness and precision, and a large number of casts can be made from a single mould without injury to it.

This, the latest of large inventions in the printing world, has supplied another link in the long chain of machines by which the printing process is carried through with scarcely the touch of a human hand, save in the direction of the mechanical powers.

The Science of Electrotyping. The electro-room used to be the arcanum of mystery to the ordinary printer. Here processes were carried on which he had no means of understanding. To get even an inkling of the secret he had to pore over dry textbooks on electricity, galvanism, metallurgy, chemistry, and mechanics. Developments in two directions have changed all that. One is the growth of technical education; the other is the substitution of the electric dynamo for the galvanic battery in the electro-room itself. To manage a galvanic battery properly a man required a clear knowledge of its principles and action, and this involved a smattering at least of chemistry and metallurgy as well as a grasp of galvanic theory. Even now the student would do well to study those sciences, if he desire to become master of the electro-room. As a groundwork he should read studiously the articles in the SELF-EDUCATOR on Metallurgy, Chemistry, Electricity, and Electrical Engineering, with special reference to acids in Chemistry, silver and copper in Metallurgy, and galvanic action and electrolysis in Electricity. In the electro-room of the present day the work is practical, and may be learned like any other trade.

The Discovery of Electrotyping. About 1839 three men, Professor Jacobi, of St. Petersburg, C. J. Jordan, of London, and Thomas Spencer, of Liverpool, appeared to claim credit for discovering that the deposit of a metal electrically corroded might by the same action be deposited on a mould with electrical affinity. This meant the discovery of electrotyping.



34. POWER STEREO-MATRIX MOULDING MACHINE

The "London Journal" for April, 1840, appeared with an electrotype plate, and Savage's "Dictionary of Printing," published the year following, gave several specimen plates produced by the process.

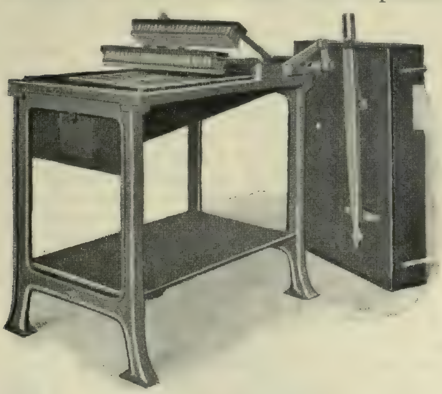
The process of electrotyping may be divided into six acts. (1) Moulding the forme;

(2) trimming the mould ; (3) treatment of the mould in the trough ; (4) releasing the shell ; (5) backing the shell ; (6) finishing the plate.

The Electro-room. The furnishing of the electro-room differs very much from that of the foundry. The equipment is larger, for the process is double. Here we have all the appliances and machinery for casting a plate and the apparatus required for forming the wax mould and depositing the electro besides.

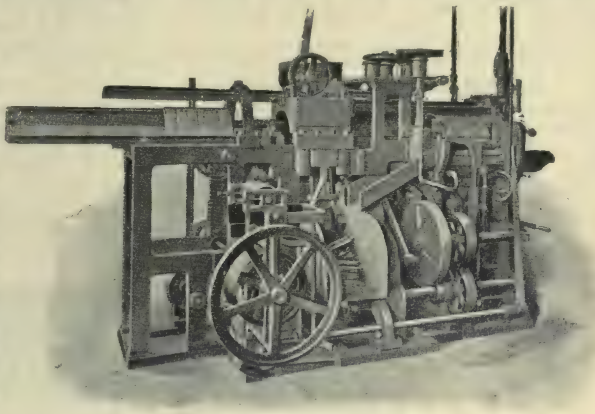
The forme is prepared in the same way as for stereotyping, but the locking-up apparatus is different. Wooden quoins and furniture should not be used in the electro-room, and cast-iron chases are unsuitable. Wrought-iron chases, heavy and strong, fitted with screws for locking up, are the best and simplest. When screwed up and cleaned, the forme is covered with blacklead brushed on to a high polish.

Wax is the main substance of the electro-mould. Every firm has its own favourite composition, but this may be taken as a fair average : 20 lb. beeswax, 3 lb. Venice turpentine, 8 oz. blacklead. The *melting-pot*, heated by a gas-ring, sits in a flat iron plate. A water-jacket round the pot distributes the heat evenly—a consideration with such a substance as wax. The wax is now poured into a moulding-case—a sheet of lead with a flange a quarter of an inch in height all round. Within a few seconds the wax has hardened, and the mould must now be pressed



36. BLACKLEADING MACHINE
(The cover has been removed)

on to the forme. Many forms of press are used for this purpose. The essential qualities of a *mould press* are power and evenness of pressure. No matter what form of press he uses, hydraulic or toggle, the workman has to learn by practical experience how to adjust the pressure to his need. After being pressed the mould is removed from the type, and put into the hand of a skilled operator, who *builds* it up, cutting down



35. THE AUTOPLATE MACHINE
Showing a cast in the rough, one undergoing the last of the dressing operations, and a finished plate. The matrix is inserted at the right-hand end and the product delivered at the left, while the refuse is caught by the waste-box, as shown.

excrescences, filling up defects, and rendering the mould solid and clear.

The Blackleading Machine. The builder has done his best, and now the mould goes on to the *blackleading machine* [36]. Outwardly this machine looks like a large box set on legs. In the box we find a moving lattice-table, and across it a pair of long-haired brushes fixed by two arms to a driving shaft. The mould is laid face upward on the table and sprinkled with blacklead. Then the box is shut, the lattice table moves to and fro, the brushes rapidly vibrate on the face of the mould, and bring it to a high state of polish. A few finishing touches with a camel-hair brush, and a rub up with the hand brush, make the mould ready for the plating trough.

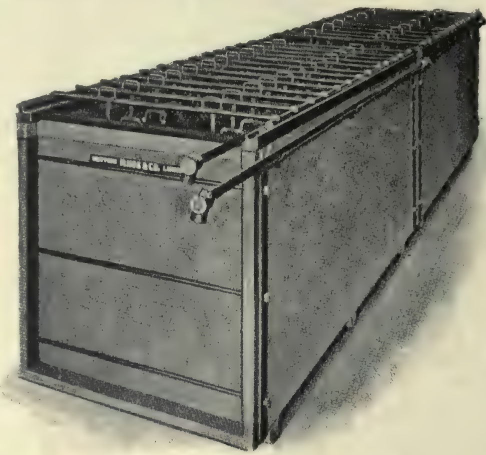
When a workman loves his work he is not content to follow mere routine practice, getting the job through anyhow ; he thinks out little improvements, and adds them to the process. One eminent practitioner, for instance, has found that by coating the back and outer parts of the mould with an insulating varnish, better results are obtained. Another has devised a method of using sulphate of copper in contact with iron filings, so as to produce a thin film of copper on the mould, before it goes into the trough, thus facilitating the formation of the plate very considerably.

The Bath. The *trough* or bath [37] should be made of wood, 3 ft. deep, 4 ft. long, 2 ft. wide, lined with sheet lead, or thick plate glass. Across the trough strong copper wires are fixed for holding the moulds, while at the side, within the trough, hang the copper plates called the anodes, literally the ways of the electric current, and practically the decomposing metal which is distributed on the mould. Water, strengthened

by sulphuric acid and sulphate of copper, fills the trough. The moulds are hung in the solution by means of copper hooks linked on the rods. Now the electric current is switched on from the dynamo, and the work of electroplating has started. With the old galvanic batteries the process took at least twelve hours for an ordinary plate, but the current of the dynamo makes a thick plate in less than half the time.

Making the Plate. The shell has formed a thickness of $\frac{1}{32}$ in., and is ready for removing from the bath. Taking the mould from the solution, the operator puts it under a stream of hot water, and frees the shell. After close examination and mending of faults, if any, the shell is laid on the backing pan, a shallow, oblong iron tray, with handles at both ends.

No amalgam of lead will join on to copper, and the backing metal is composed of lead, antimony, and tin. How is the difficulty to be got over? The electrotyper has already answered the question by finding in granulated tin a metal combining readily with both metals. Having been sprinkled with enough tin to cover the shell with a thin film, the pan is suspended over the square metal melting-pot on hooks geared in a frame above, and slowly let down into the molten metal. As the pan comes within the heat of the pot the tin melts, and spreads all over the inside of the shell. Then the pan is lifted on a level frame, and molten lead poured on to the required height.



37. ELECTROTYPING TROUGH

The finishing of an electro-plate requires more delicate handling than the dressing of a stereotype plate, but the appliances and methods are practically identical.

Superseding the Electrotype. As may be readily understood, the foregoing process, consuming six hours of time, hardly contented the publishers of illustrated journals. Up till 1891, however, it seemed scarcely possible to do better. Common stereotype plates could not be made to reproduce fine illustrations, and the electrotype was the only apparent alternative. But in that year, Mr. Harvey Dalziel invented a process which completely changed the aspect of affairs, and gave into the hands of the printer a new and highly efficient method, capable of producing plates as swiftly as stereotyping, and as finely as electrotyping. Dalziel's process was invented in 1891. Previous to this date all high-class illustrated productions had to be produced by the expensive and lengthy process of electrotyping, which, a sa general rule, took about six hours.

The Dalziel Process. Dalziel's invention consists of a specially prepared plastic mixture (the ingredients of which are his secret) spread on a sheet of prepared paper. This is impressed as a mould on the blocks or formes required to be reproduced. So perfect is this mould that it yields facsimile the finest detail in the original half-tone or other blocks. The stereo-plate is made by running a specially prepared hard metal into the mould. These two operations take less than one hour, the result being equal to, if not better than, the finest possible electrotype. When a very large number of impressions is required from Dalziel stereos, they are dipped in a nickel depositing bath for a further period of 15 to 20 minutes.

The merits of the invention may be appreciated by the fact that many high-class publications, such as the "World and His Wife," are printed entirely from these stereos.

Mounting Plates. Stereotype, electrotype, and all kinds of metal plates require to be mounted on a bed of wood or metal to make them equal to type in height. Various forms of blocks, or mounts, have been ingeniously devised. Typefounders and engravers who make a business of supplying illustrations to the trade usually mount them on solid mahogany, professedly of type height, though sometimes the printer finds good reasons for questioning the validity of the profession. [See TYPEFOUNDING.] Wood is not so reliable as metal, the wetting and drying, heating and vibrations to which formes are subjected in the various processes tending to warp and split even the best wood. Of late, metal mounts have come into almost universal use for stereotype and electro plates. Different patents are used, but the principle of them all is nearly the same. Metal block-mounts in two parts readily lock together, making up to different sizes, and clasping the four sides of the plate by narrow rims and brass catches. These blocks or mounts not only make mounting an easy matter of putting two pieces together; they also facilitate the work of imposing successive formes. All that the workman needs to do in such case is to unlock the forme, loosen the catches, lift out the plates already printed, and put in the fresh plates.

Continued

VARIETIES OF BASKETS

The Square Basket and its Manufacture. Ornamental Borders. Oval and Fruit Baskets. Workbaskets. Wicker Chairs and Crates. Toys

BASKET-MAKING continued from page 5490

As a general rule, the framing of a *square basket* is much stronger than the skeleton of a round one, though, of course, small square baskets may be built up on very fine lines, like those shown in **5** and **15**. Suppose we elect to make a square basket 18 in. by 12 in., or thereabouts. As many square baskets are shallow, this one need not be deeper than 8 in.

The Bottom of the Square Basket. Selecting eight unwatered sticks 21 in. long, and about ½ in. in diameter, we straighten those of them which may be crooked with the commander [**2**, M, page 5489]. The two thickest are placed in the screw block [**3**], about 11½ in. apart., and fixed in position. Next, the others are put into the grip of the block, the thinner ends alternating with the thicker, to balance. It is obvious that the difference between the diameters of all the sticks must be as slight as possible; but a slight tapering is unavoidable. Having securely fixed the bottom sticks by their ends in the block, the next thing is to begin filling up.

The sticks standing up vertically in the screw block, we take two rods, fairly long and equal, and begin by a *pair*. Lay the first rod flat against the front of the second stick from the left hand side, the butt projecting a little over the third stick. While pressing the butt firmly against the second stick with the left thumb, bring the rod round behind the outside stick to the front, and then round behind the second stick, crossing the butt, and round to the front of the third stick. The projecting butt can be fixed behind the third stick. Introducing the butt of the second rod behind the third stick, and beside the other butt, bring it round in front of the fourth stick. The first rod, if it is to pair regularly, must come behind the fourth stick, and so we now have a pair of rods working over each other. At the outside stick to the right hand the pair are twisted back to start another row of weaving, and they are woven together across the breadth, making a sound base for this side of the bottom.

5. BORDERING A SQUARE BASKET

Filling up the Bottom. The whole bottom might be filled up by a continuation of the *pair*; but the common way is to fill up with *randing*, or for coarse work, *slewing*. With a single rod the weaving is continued to and fro across the sticks, till within about an inch of the end. A precaution has here to be observed. The natural effect of the pulling force of the woven rods is to draw the sticks closer together; if that tendency were allowed to go on unchecked, we should find one end of the bottom several inches narrower than the other. Practised workmen keep the structure in shape by the eye, but the beginner has not acquired that sense. A simple gauge may be made with a rod, bent at both ends to the size. Applying this at intervals to the bottom, as the work of filling up proceeds, the basket-maker keeps his work straight. Having filled up to within a short space of the end, we apply another pair of rods in the same fashion as was done at the beginning. Some consider it enough to work a doubled rod over that end; but for the sake of symmetry both ends should be made alike.

The Sides. When the bottom has been firmly woven it is taken out of the block, and the protruding ends by which it was held cut away close to the weaving, the remainder left being about 18 in. long. Next we select the stakes for the sides. For a basket this size we require eight for each end, and thirteen for front and back, making in all 21 pairs of rods. The stakes for the ends are cut at the back to a long point, and the point of each is thrust into the weaving of the bottom, one beside each stick. Like the stakes of the round basket the side stakes are given a slight cut on the inner sides, and turned sharply up close to the weaving.

The stakes at front and back are treated differently. It is necessary to drive the stakes through the outside bottom sticks. Make holes with the bodkin in the stick, at equal distances apart; sharpen the ends of the stakes, and drive them through, taking care not to split the sticks. This done, prick up each with the knife, on the side next the stick, and turn upwards. In order to keep the stakes from falling away at all angles, gather the top ends within an improvised hoop or holder.

Why Baskets are so Strong. We wish to make the basket capable of bearing a good weight and standing some wear. We therefore form the bottom courses with *wales* of three rods. The basket should be held firm on the workboard by a bodkin or iron weight. Put the first rod in between the first and second stake to the right, and bring it round between the second and third. Insert the second rod between the second and third stakes, and bring round between the third and fourth. Do the same with the third rod, passing it in between the third and fourth, and bringing it back between the fourth and fifth. Now begin weaving. Carry the first rod across the second and third, bring it round behind the fifth stake, and out to the front again. Naturally, the other two rods pass round the successive stakes, the second round the sixth, and the third round the seventh. Each rod is taken in turn and passed behind the stake next to the one already passed. Once we have made a beginning with such a method of weaving, the rest is easy, because it is simple repetition. Having made the

breadth of *upset* we think necessary, the *wale* can be finished off evenly, and the single stroke called *randing* adopted to fill up the greater part of the sides.

Finishing and Strengthening Courses and Borders. We might elect to continue randing nearly to the very top, and then work in a pair to finish off, relying on that and the border to keep all tight. But another waling course is considered better for strengthening the head. A strong and ornamental course can be made with four rods worked one over and after the other, in the manner already described. When well done the waling resembles a rope in appearance, and gives a firm backbone to the rest of the structure.

The simplest and most easily-learned border is that shown in our illustration of the square basket [**5**]. The stakes have not been cut off at the height of the weaving, but remain standing up 3 ft. or 4 ft. of bare rod. Holding the knife in the right hand, prick down each stake on the right side and bend over from left to right, so that it comes close down over the last round of weaving. Having bent down the number of stakes required for a start—three, four, or five, according to the width required for the border—pass them under and over each other in regular succession. In order to combine a stake with, say, five other stakes, its length must be proportionate, because they are all at equal distances from one another. Compared with a three-stake border, the five-stake one must be nearly double the thickness, because nearly double the length of rod has been put round the same size of basket. There is, however, an obvious limit to this method of bordering. Cut off the projecting ends of the stakes with the picking-knife, and lay them aside for the foot, if such be needed.


6. PUTTING IRONWORK ON SQUARE BASKET

The Rope Border. Another favourite and simple border which is used in fancy work is known as the *rope design.* To begin this, bend No. 1 stake in front of No. 2 and behind No. 3. No. 2 stake in front of No. 3 and behind No. 4. No. 3 stake in front of No. 4 and behind No. 5. No. 4 stake in front of No. 5 and behind No. 6.

This gives us two pairs. Now take No. 2, the second of the first pair, and bring it up in front of No. 5 and behind No. 6, and bend No. 5 over it. This leaves us with another two pairs. The upper one of the first remaining pair will be No. 4; bend this in front of No. 6 and behind No. 7, bending No. 6 over it. Continue right round, and a rope border will be formed. But, note that the first four rods did not follow the rule; in fact, they could not, having nothing to go upon. Now, however, No. 4 has the last to work with and No. 1 the fourth last. Pulling them out, we combine them with the rest according to rule. All the points are sticking out to the front, and our next object must be to insert them securely into the weaving and form the whole border. Bring the point of No. 1 over the point of No. 2, and insert it into the next opening made by the curving stake beyond. By so doing, we double the curve and form the second strand of the rope. Perform the same operation with every point, and the result will give a fine rope border to the basket which we are making.

Plaited Borders. Some borders are made by plaiting four pairs of rods together in the simple manner known as the *foursome plait*—that is, one pair of rods always crossing over two [**18**]. This makes a broad and rather pleasing border, capable of standing a considerable amount of tear and wear. The number of different strokes in sound bordering is not great, but practice enables a basket-maker to bring out a large variety of patterns.

The Foot. To make the foot, turn the basket bottom upwards, and insert the tops cut from the stakes, after the border has been laid down alongside the stakes as if for another four sides. Weave two rounds of waling on the foot-stakes; then prick them down and border as has been described in the finishing of a basket. It wholly depends upon the thickness of foot desired what number of stakes are laid down.

Handles. The position of the handles is sometimes on the border, sometimes on the sides. In the former they are made up of rods twisted round each other and the border in a very simple way. Push the ends of two rods, at about a hand's breadth apart, in through the border and down beside a stake each. Bend over the one from left to right, and pass it through under the border on the right side of the other rod. Wind the second rod three times round the bow thus formed, and pass it through under the border; then bring it back over the border, and lap it round the bow again; repeat the action. Now bring the first rod into play, and lap it round the bow three times, performing the circle thrice in similar fashion. When finished, the tops are secured, and the handle made firm and complete. The side handle is made in similar fashion at any point on the sides or ends before the border is laid down. The basis of the *cross handle* is a hoop, worked over with rods on a rope pattern. The ends of the hoop are sharpened for driving into the weaving, each end beside a stake in the side of the basket. Bent round inside the basket to the outside, the rods are wound spirally on the hoop, and at the other end twined through the structure of the basket.

Lids. The lid of a large square basket, or hamper, if flat, is made in the same way as the bottom, with the difference that the outside sticks are thicker in proportion, and the size is a margin larger all round. If a trunk lid is required, we proceed as though about to make a shallow square basket, to hold the other within it tightly. The top of the lid is treated as the bottom of the shallow basket, and the sides are staked, upsetted and bordered, just the same, the whole being made to the depth of the trunk required.

Iron Fittings. It is quite possible to make baskets of the strongest and most elaborate kind with nothing but willow rods; but a stronger way of putting on the fittings is to call in the aid of iron. The hinges of the lid, for example, may be, and very often are, made of osier staples linked together and deeply thrust into the weaving. A stouter method, however, is to use a set of iron staples and an iron rod for the hinges. Again, the fastenings of the lid of the hamper, which is employed in carrying many classes of valuables, may be made of willow staples

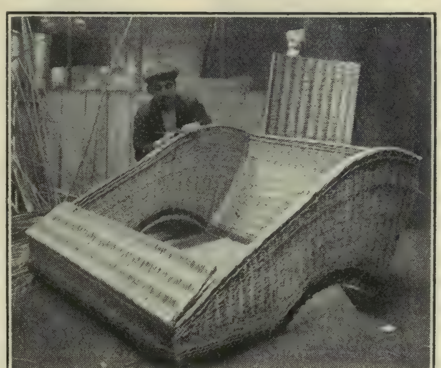
on lid and basket, secured by a padlock. But the better, safer, and more usual style of fastening is that shown in our illustration [**6**]. The hinged plates of brass are firmly stapled into the lid, and the tongue is brought over the staple fixed in the front of the basket. The fixing of these needs no direction.

An interesting departure in the use of iron in baskets is that known as "Parker's patent." The special feature of this device is the interweaving of a wrought-iron rod throughout the main parts of the basket, including the handles. For baskets employed in heavy work, such as coal transport or rubbish removal, the idea is very serviceable.

7. MAKING A WICKER CHAIR

Oval Baskets. In the main, the making of oval baskets, for carrying linen and other such goods, involves principles little different from those of the round basket; but the bottom is constructed in a special way. To form a base for the bottom, we require a *slath* made up of sticks and rods woven alternately over and under each other. The number and thickness of the sticks is determined by the size and quality of the basket, but four or eight tying rods are required according to the size or fineness of the basket. Working the rods in two equal divisions, the one division directed from right to left and the other from left to right, crossing and interweaving the rods with the sticks and each other, we lay a sound foundation for the bottom of the basket. After the structure has been given form, the bottom sticks are opened out and filled in by weaving, just similar to the round basket. Whether filled up by randing or slewing, the bottom is generally edged off with a pair, to give stiffness to the grip on the stakes.

One thing has to be noted about the sides of this and other baskets, and that is the slant which may be given in regular measure all round. On a bottom 14 in. in diameter, we may spring to a rim 22 in. or more or less in diameter. This involves a slant which must be carefully observed at all points and measured occasionally.



8. FINISHING A BASKET FOR A MOTOR-CAR

Fruit Basket with Lid. Flat, shallow baskets for holding fruit are always sure to be in demand at the fruit season, and the basket-maker usually plans to fill up odd times in making them. To anyone who has acquired the ability to make an ordinary oval or square basket, fruit baskets offer no difficulty. But sometimes the latter are made with lids which have some special characteristics. Let us attend to one of these for the short space necessary. Take a stake, mark off on it a little more than half the length of the basket, the breadth of the basket, and the half again with a margin. Make notches at the two marks, and bend the ends at right angles. This will form half a square to lie along the top rim of the basket; it is half the outside frame of the lid. Cut the ends to a slant. Prepare the other half of the frame in the same way, and see that the ends are cut so as to join neatly.

Secure the ends of the half you are going to work first with a looped rod to the breadth of the lid, and then select four or more *scallom rods*, according to the size of lid required, and twine the ends on the bow at equal distances. Shape two fairly thick sticks the length of the whole lid, and lay them ready. Now use a long weaving rod, lay the butt across the bow, with a bit to spare, and twine round the bow rod at the left side. Bring this top over the first scallom rod and round behind the first stick. At the same time fetch the butt behind the scallom rod, and bind it tightly over the first stick. Weave the two ends alternately across the whole framing, and continue with other weaving rods till the half is filled. Work on the second half of the bow, and complete the lid. See that the jointings are secure between the two halves of the bow. Various kinds of fastenings are adopted and the methods of hinging on the lid are also matters of choice. In any case, both fastenings and hinges are easily made.

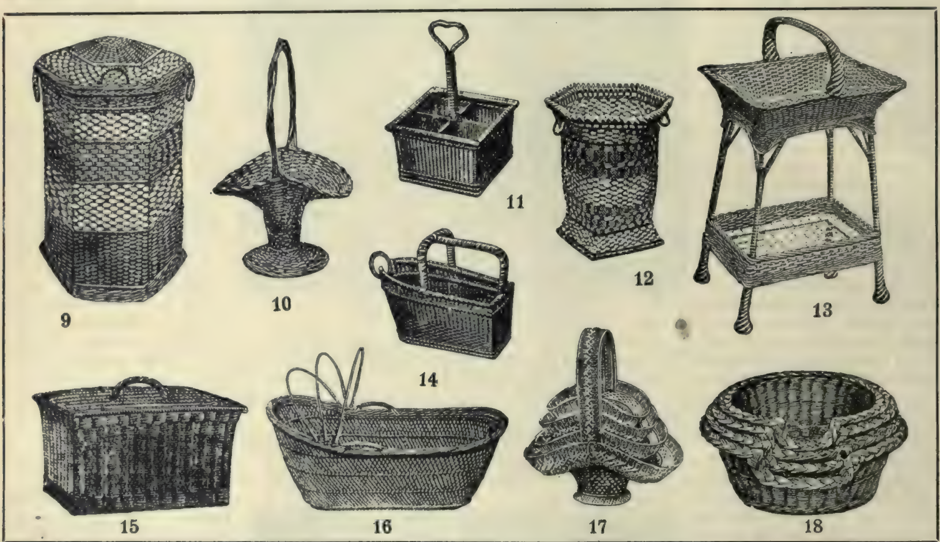
Double-lid Baskets. The *double-lid* basket is a neat style of basket used for carrying drugs, glass, or other small parcels of fragile articles. No new principle is involved in the making of these baskets, though the workmanship required is finer. One thing must be specially noted—the framing is much heavier in proportion to the weaving than in ordinary baskets. In fact, the higher classes are woven with skeins. The double-lid sometimes puzzles the beginner a little, but it is little more than the two halves of the flat basket wrought and finished separately, without, of course, the strong sticks. Between the two lids a bridge is made across the basket, formed of rods neatly wound together with light osiers or skeins.

Round Cane Baskets. Various pretty round baskets may be made of cane-pith. Being more flexible, and therefore easier to work than osier, cane-pith is utilised for every kind of small basket. A simple and very useful round basket is made

by crossing over two sets of canes, tying them together, weaving a round bottom with in-and-out plaiting, turning all the canes up, and continuing weaving to the top of the size designed. As a rule, the head is simply finished off with a rope or *trellis* border. For this purpose, the stakes, or radials, are left very long. We have looked at the rope border, let us glance now at the trellis. Turn down stake No. 1 behind stake No. 2, and thrust into the side of No. 3. By this method, we form a series of hoops on the top of the basket, showing a very graceful border.

Fancy Strokes. At the beginning, whenever that was, the basket-maker taught the weaver; but the worker of yarns has far outmastered his teacher, and now he can learn how to combine patterns from him. By varying the length of the crossings of the plaited yarns the clothmaker brings out fine effects, and the basket-maker has also learned the secret. Using flat stakes for the sides of baskets pretty effects are produced by making a square of alternate crossings surrounded by skeins passing two uprights at a time. Zig-zags, checks, stripes, and even figures are produced in this way. Stained canes, or osiers, give an even wider range to the artistic taste.

Fancy Shapes. The rage for cheapness has spoiled somewhat the pleasure of the worker in the trade. Many of the fancy baskets which obtain a large scale are mere framings twisted, or what is most atrocious, nailed together, and woven in with fancy plaitings of straw. But the genuine article obtains a steady market if it is also tasteful. A neat workbasket can be made of light canes on a wooden framing, and with handles coming from the four corners to the centre. But we prefer the same model formed wholly of cane. It is not so easily worked, but the results are better. Cut a rod of cane-pith, measure into four equal parts, mark, notch with a picking knife at the corner points, bend so as to form a square, and bind the ends together. Select other eight canes of a size or two thinner, weave them across the frame, four one way and four the other. Into each corner fix a small upright. With skeins weave double a solid web along the whole frame. Bend up the crossing canes to form the stakes of the sides, which may be of any nice pattern the maker may fancy, the main thing to keep in view being the stability of the basket. If the pattern is to be an elaborate one, additional stakes must be put in. Taking advantage of this, we might make a fine trellis. Having thrust the added canes well into the bottom weaving, we bring them round on a level with the other stakes. First secure all with a double row of weaving; leave an open space of about one-third the height of the sides, and weave another double row. With the ends of the added stakes and the stakes of the frames we have ample material for making a close design of trellis-work of any pattern which may be fancied. Cane-pith being so flexible may be twisted to any shape without injury, if the fibres be kept flat.



VARIOUS ARTICLES IN WICKER

9. Sexagon fancy soiled linen basket of wicker and rush plait **10.** Flower basket **11.** Partition basket for sauce **12.** Fancy waste-paper basket sided up with straw plait and rush plait **13.** White wicker work table **14.** Decanting basket for wine **15.** Buff picnic basket **16.** Bassinette, cross-fitched **17.** Nest of flower baskets **18.** Nest of dog baskets with plaited borders

Varieties of Wicker-work. The basket-maker and wicker-worker put out a large and wide variety of articles [**9–18**], ranging from the toy suite of furniture of the dolls'-house to the comfortable wicker armchair [**7**], from the baskets of Easter eggs delightful to the children to the crates carrying the parcels of the Post Office, and the bodies of motor-cars [**8**]. After he has learned the mysteries of randing, slewing, fitching, cross-fitching [**16**], staking, upsetting, and waling, the young basket-maker is on the way to a mastery of his trade which practice alone can give.

The photographs which illustrate these articles have been taken in the works of Messrs. G. W. Scott & Sons.

Figure **4** is from an engraving of a waste-paper basket made by Mr. Thomas Okey for the Society of Arts to exemplify the chief strokes used by the basket-maker.

BASKET-MAKING *concluded: followed by* CANE AND BAMBOO WORK

PERCUSSION INSTRUMENTS & BELL-RINGING

Including the Drums, Cymbals, Triangle, Seraphine, Dulcitone, Castanets, Celesta and Glockenspiel, and the Art of Bell-Ringing

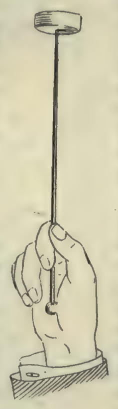
Continued from page 5447

By PAUL CORDER and ALGERNON ROSE

THE DRUMS

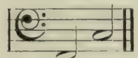
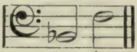
By Paul Corder

THIS group of instruments, although of comparatively small importance musically, is one which, of recent years, has filled an important place in orchestral music. With the exception of the kettle-drum, none of these instruments can be said to produce a sound of definite pitch, their use being almost entirely restricted to accentuating the rhythm. The percussion instruments most frequently met with in modern scores are these: kettle-drums, side-drum, bass drum, cymbals, triangle. These will be taken in the order mentioned above, and instructions given to enable the student to master their peculiarities. [Other instruments belonging to this group follow.]



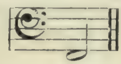
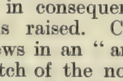
HOW TO HOLD A DRUMSTICK

The Kettle-drums. The kettle-drums, known in France as *timballes*, in Italy as *timpani*, and in Germany as *pauken*, are the most important of the percussion instruments, and consist of a hemispherical copper body, with a cover made of calf-skin vellum. The vellum is secured to a ring which fits over the body of the instrument, and, by means of screws placed at equal intervals round the circumference, the vellum head may be more or less strained, thus producing notes of varying pitch. The body is supported, usually, by three sliding iron legs, the length of which may be altered and fixed with a set-screw to regulate the height of the instrument.

Two kettle-drums are usually employed in the orchestra, the larger having a compass of:  and the smaller one:  so that the extreme notes available should lie within the octave, although these limits have been occasionally exceeded by a semitone in both directions. The larger instrument is sometimes called the F, and the smaller the B♭ drum, from the lowest note given by each.

The sticks used in playing the kettle-drums are generally made of some light wood: cherry or white beech are frequently used. They are 14 in. in length, with a diameter of $\frac{3}{16}$ in. to $\frac{3}{8}$ in., the head consisting, usually, of a disc of rubber, cloth, or piano-felt, having a diameter of $1\frac{1}{2}$ in. to 2 in. The stick should be provided with a small knob or other device at the extreme end, to prevent its slipping from the player's hand.

Tuning the Drums. The first and greatest difficulty to the student will be to acquire the art of tuning the drums to any notes required. The instruments should be placed side by side in front of the player, the small drum to the left, the larger to the right. In some orchestras this position is reversed, but the arrangement given is the more usual. In this country it seems to be the general custom for the drum-heads to be horizontal, but the method on the Continent of tilting them towards one another has a decided advantage in crossing from one instrument to the other. It will be noticed that each of the screws to be used in tuning terminates in a brass T-shaped handle, with the exception of the one on each drum that is nearest the player. These two handles, which would be in the way when playing the drum, are omitted, the two screws being turned by a separate key provided for the purpose.

It must be borne in mind that by turning the screws in a direction similar to that taken by the hands of a clock the head is tightened, and, in consequence, the pitch of the drum is raised. Conversely, by turning the screws in an "anti-clockwise" direction the pitch of the note is lowered. Now, starting with the head of the larger drum quite slack, tighten all the screws successively, until each is felt to "bite" the thread of its nut; then, from this point, give each screw, say, half a turn, always including the one worked by the separate key. and omitting none. Strike the head lightly with the stick or the fingers, and, if necessary, tighten all the screws a little more until the note  is sounded. The drum must be struck near the rim, and never in the middle, where the tone is harsh and indistinct. Try whether it is in tune all round the edge, as, owing to the unequal thickness of the vellum, the intonation frequently varies. Such inequalities must be corrected by the screws nearest the faulty spots. The smaller drum may now be tuned similarly to .

Until the student has had some little experience in tuning, the notes required may be sounded on a piano or other instrument for his guidance. But later he should be able to dispense with such help. The sound of the A given by the orchestra when tuning may be of assistance in determining the pitch at first, but having tuned, as described, to F and B♭, any other notes can be found from these. For example, tune the B♭ drum up to C, tightening all the screws as before, and comparing the note with the F of the larger drum, until the interval of the perfect fifth

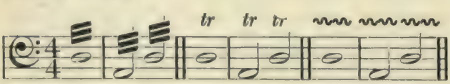
(F to C) is recognised. It is advisable in testing the note to use a light flick of the finger in preference to the drumstick, as the note is more clearly heard; moreover, there is less disturbance if the tuning takes place during the progress of a musical performance. If the drum has been tuned too sharp, it may be somewhat flattened by the pressure of the hand in the centre of the vellum. This change of tuning would be indicated in the band part by the words "Muta B♭ in C."

The student should practise tuning to various notes until perfect facility is obtained, even while the orchestra is playing in a totally extraneous key.

Many mechanical devices have been invented to abolish this tedious system of tuning, but they are so seldom seen in this country that it is not thought necessary to describe them.

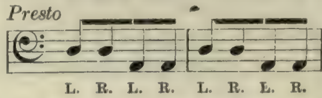
The correct position for holding the stick may now be considered. It is the same for both hands. The stick is gripped between the thumb and the side of the second joint of the forefinger, which form, as it were, a pivot on which the stick can swing. The middle finger, which is below the forefinger, should touch the stick near its extreme end, and, in conjunction with the ball of the thumb, should control its movement. The other two fingers should not touch the stick at all. The illustration on the preceding page will make this position clear.

The Roll on the Drum. In playing a roll—one of the most frequent and useful effects of the drum—the middle finger gives a flick to the end of the stick, causing the head to strike the drum, and as fast as it can be made to rebound off the drum-head this is repeated, the two hands performing this action so that the strokes alternate with one another, and are not simultaneous. For a *pianissimo* roll, this finger movement alone will be sufficient, but when more tone is required it must be supplemented by a loose movement of the wrist; the forearm should be used as little as possible, and the upper-arm not at all. The student, if unable to obtain access to the drums, may readily practise the roll with a pair of timpani sticks on the seat of an ordinary cane chair, and should not find much difficulty in acquiring the necessary skill. The roll is indicated in the music by one or other of the following signs, the meaning in each case being identical:



Care must be taken in playing single notes to let the stick bounce off the vellum as soon as the note is struck, as otherwise the tone will be destroyed; at the same time, the drum must not be permitted to sound for longer than the value of the written note, but must be muffled with the finger-tips or the hand.

As a general rule, the drum on the right hand is played by the right hand, and that on the left by the left hand; but exceptions to this are numerous. Several notes in quick succession on one drum would be played with the two hands alternately, and in certain cases the hands require to cross:



Instances of this cross beat are numerous.

In former times, when it was customary to give the kettle-drums only the tonic and dominant of the key to play—*i.e.*, the first and fifth, the notes were always written as C and G, whatever the sounds to be produced, the actual notes being indicated at the beginning of the movement; thus

Timpani in E♭. B♭.

would be played

This custom has now been abolished since tuning other than the tonic and dominant has been required.

Frequently three or even four drums are employed in the orchestra, and even if not actually required together, the use of a third obviates the necessity for so many changes of tuning.

In playing in an orchestra the student will have to accustom himself to the counting of many bars' rest. This is not among the least of his difficulties, especially if it is necessary to alter the tuning of the drums in the meantime. Nothing but practice can give facility in this matter, practice until the process of counting becomes almost automatic. It is of great assistance in finding one's way during a long rest if the band part is supplied with cues giving a prominent phrase of another instrument; also, pauses and changes of time should be noted, as these form landmarks, as it were, which enable the student to keep his place in the music. The foregoing remarks apply equally to the other percussion instruments now about to be considered.

The Side-drum. The side, or military drum consists of a wooden or metal cylinder with a vellum head at each end, tightened sometimes by means of screws, sometimes by cords and leather braces. In the orchestra it is fixed in front of the player in an upright or somewhat inclined position, the top head alone being struck. The lower head has several catgut cords stretched across it, called *snares*, which rattle against the skin and give the drum its peculiar, characteristic rasping tone.

The sticks are of hard wood, and are held in this way. The right hand grasps the stick near the end with all the fingers clasped round it, so that the knob shall strike the drum in the middle; the left hand is held with the palm turned towards the player, the stick clasped near the end by the thumb and forefinger, and then passing between the middle and third fingers.

To play a roll on the side-drum is by no means easy, and will require considerable practice to enable the student to master it. It differs from the roll on the kettle-drums in that two notes are struck with the left hand and two with the right, alternately. In making a crescendo during a roll, begin *pianissimo* near the hoop and advance nearer the middle as the tone increases, reversing the process for a *diminuendo.* The same methods of indicating a roll are used as described for the kettle-drum.

It is sometimes required in funeral marches and pieces of similar character to muffle the drum; this is accomplished by inserting a piece of cloth between the snares and the vellum, which prevents their vibrating; or a still more muffled effect is produced by enclosing the whole drum in a bag and playing through the cloth. The Italian word *coperti* is used to indicate muffling.

Music for the side drum is generally written in the treble clef; the exact note used is quite immaterial, as the drum should be of indefinite pitch.

The Bass Drum. The usual form of this instrument, that of a short cylinder of large diameter with vellum heads, will be familiar to everybody, and although there is a variety frequently met with in orchestras which resembles a big tambourine, only one side being covered with skin, the manner of playing is the same in either case. The drum is mounted on a stand or suspended from a frame, and except in military bands one side only is used. Generally only one stick is employed, the head terminating in a large knob covered with wash-leather, or sometimes made entirely of piano-felt. A smaller knob is not infrequently furnished at the opposite end of the stick, and in playing a roll the stick is held in the middle, and by a rotary movement of the arm each knob is made to strike the drum-head alternately. Another (and in many cases preferable) method of playing a roll is by means of a pair of timpani sticks held in the manner described for the kettle-drums, the only difficulty being that the drum-head is vertical instead of horizontal, as with the timpani.

In playing single notes the stick should be held loosely near the end, and should not move at right angles to the drum-head, but should rather sweep past it, striking the blow in passing. When a short note is indicated the vibration of the vellum must be stopped with the hand.

Music for the bass drum is written in the bass clef; the actual note used is, of course, quite immaterial, as the sound produced should be of indefinite pitch.

THE CYMBALS

The cymbals consist of circular plates of hard brass, which are held, one in each hand, by leather thongs fastened through a hole in the centre of each.

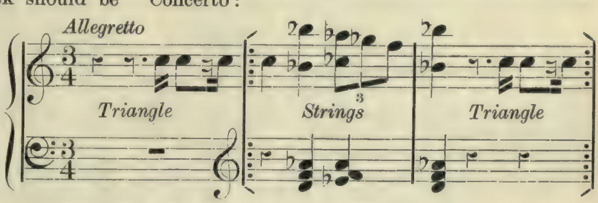
There are several effects to be obtained from this instrument, the most usual being the striking of the two together. This should be done with a sweeping movement of the cymbals past one another in order to obtain the best possible tone. Begin the stroke with the right hand somewhat higher than the left, and finish it with the left hand above the right (or vice versâ). Practise this stroke with varying strength from *pianissimo* to *fortissimo.*

Very frequently the bass drum and cymbal parts are written together, one player being supposed to manage the two instruments. In this case one cymbal is bolted firmly to the drum, the player wielding the other with his left hand, while the right is occupied with the drum-stick. This practice has many objections, and wherever possible the cymbals should be played by a separate player.

In playing a roll on the cymbals, unless otherwise indicated, the two cymbals are held close to one another, and the right hand made to rock quickly backwards and forwards so that alternate sides of the right-hand cymbal strike that in the left hand, which is held stationary. It is not easy to obtain much tone by this method, and a roll is frequently indicated to be played "*with drumsticks.*" In this case one cymbal should be suspended by its leather handle, and a roll executed on it near the rim with a pair of timpani sticks, in the manner described for the kettle-drum. The tone thus produced is peculiarly penetrating and sinister. Single strokes with a drumstick are sometimes required, for which purpose the bass-drum stick is to be preferred.

THE TRIANGLE

The triangle consists of a rod of steel bent to the shape of an equilateral triangle, the ends of which, however, do not meet. It is suspended from one of its angles, and is struck with a steel rod, producing a clear, penetrating note of indefinite pitch. Its employment in the orchestra is very limited, as it has scarcely any range of tone. Its chief use is to mark the rhythm in dance music. The only instance the writer can recall of the use of the triangle as a solo instrument is in this passage from Liszt's Piano Concerto:



The triangle notes, although written as C, do not, of course, sound so.

A shake or roll is sometimes required, and is played by rattling the striker across an angle of the instrument, it being necessary to guard against the tendency of the triangle to revolve meanwhile if, as is usual, it is suspended by a piece of string or gut.

Triangles are made of various sizes, but large ones are unsuitable to the concert-room. The smaller the instrument the shriller its note.

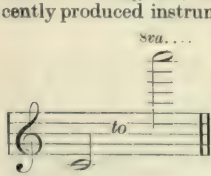
CELESTA & GLOCKENSPIEL

By PAUL CORDER

These two instruments, although dissimilar in many respects, are taken together on account of the subordinate position they occupy among musical instruments. Although they have a tolerably extensive compass, their use at the present time is solely confined to a few orchestral compositions, no solos having been written for either instrument by any composer of note. Nor is it difficult to understand why this is so; although the tone of the celesta is quite the most pure and beautiful of any instrument, yet it lacks variety and means of expression. *Fortissimo* and *pianissimo* have for the celesta hardly any meaning, and the clear, bell-like tone becomes monotonously irritating to the ear after a short time. Nevertheless, in its proper place in the orchestra the celesta is unequalled, and one need only refer to the third movement of Tschaikowski's charming "Casse-Noisette Suite" to call to mind the delicious effect of one of these instruments used with due discretion.

The Celesta. The celesta, as made by M. Mustel et Fils, of Paris, has the appearance of a small pianoforte, being provided with a keyboard similar to that instrument, but of less compass. The interior mechanism consists of a series of metal slabs with resonators, which are struck by hammers actuated by the keys. It will be assumed that the student who is desirous of playing this instrument knows something of the pianoforte [see PIANOFORTE, page 1210], in which case we need only point out in what respects the celesta differs from the superior instrument.

Its compass is generally considered to be as shown below, with all the intermediate semitones, but the makers have lately been extending this, and have recently produced instruments having several notes below middle C. But these low notes seem to be very poor in quality and weak in intonation; certainly the higher part of the instrument is the more effective.

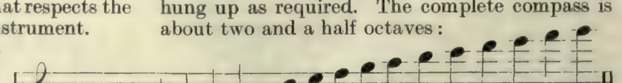


In order to avoid a multitude of ledger lines, composers sometimes write an octave lower than the part is to sound; but this custom is by no means uniform, and the executant will often have to use his discretion in deciding what are the composer's intentions.

The very limited powers of tone variation possessed by the celesta have already been mentioned, and although, with care, a good *piano* can be obtained, anything like a *forte* is out of the question. Moreover, in some instruments, if not in all, an appreciable amount of force is necessary to make the note "speak" at all; an exceedingly light "weight touch" such as would produce a perfect *pianissimo* on the pianoforte seems insufficient to actuate the mechanism of the celesta, and may result in no sound at all. For this reason evenness in arpeggios should be carefully practised as softly as possible. The following passage from the "Casse-Noisette Suite," already referred to, will make a capital study.

The Glockenspiel. The glockenspiel, or carillon, is an instrument of very different appearance, although it is more akin to the celesta than might be supposed at first sight. It consists, essentially, of a series of steel bars, which are struck with a light wooden hammer; but, unlike the celesta, these are struck by hand, the steel bars being suspended in a frame. In England this is generally a brass "lyre" shaped head supported on a stand; strings are stretched horizontally across this, on which the steel notes are hung, one above the other. There is another variety of this instrument, in which the steel bars are laid horizontally in a frame, but this is not often met with.

Usually, only as many notes as are wanted at the time are brought into use, extra notes being hung up as required. The complete compass is about two and a half octaves:



including all the intermediate semitones. The actual sounds produced are an octave higher than given, and are sometimes written so by composers. As these notes are sold separately, the student should test them before buying, for they vary considerably in purity of tone.

The tone of this instrument is much brighter and more penetrating than that of the celesta, and very quickly wearies the listener. Its range of tone is likewise exceedingly limited, but in this case it is uniformly loud, a *pianissimo* being an impossibility; or, more strictly speaking, its tone is so penetrating as to predominate invariably over all other instruments.

A difficulty to one not accustomed to these instruments is to remember that the notes in use do not necessarily represent consecutive degrees of the scale, nor are they always of the same set, but vary according to circumstances. However, each is clearly marked with its name, and by keeping the highest at the top of the frame, descending according to pitch, there is no occasion for any confusion.

The manner of hitting the notes is quite simple; a smart tap with the hammer, which must be allowed to rebound instantly, is all that is required, but it may be advisable to stop the notes from vibrating too long by means of the fingers of the other hand. Sometimes two hammers are used, one in either hand, and certainly the second one is a great help in executing rapid passages.

The part written for the glockenspiel by Mozart in the "Magic Flute," beginning

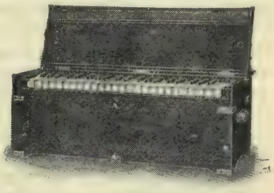
is impossible on the instrument just described, and is intended to be played on a glockenspiel furnished with a keyboard. With a little alteration the passage could be played on the celesta, for which instrument, had Mozart lived a century later, he would most certainly have written it. In Handel's oratorio "Saul" there is a somewhat similar passage, which is written as though for a transposing instrument in G—that is, a fourth lower than it is meant to sound. [For a more detailed explanation of transposing instruments see the HORN.]

In conclusion, half an hour's practice at any of these instruments will do more for the intelligent student than pages of written description.

THE SERAPHINE

In an orchestra or in a church, in conjunction with the organ, the seraphine represents in tone the effect of a carillon. Whereas, in the glockenspiel, small steel bars are substituted for bells, in the seraphine—used in certain modern orchestras—thin steel reeds, beautifully voiced, acted upon by coiled springs, are connected with a keyboard. Rapid articulation is thus facilitated. Moreover, the tone is increased or diminished in force by wind pressure, the feet of the player working a pair of small bellows as in a harmonium. Although the notation to be played may appear simple, so penetrating is the tone of the instrument that the slightest mistake is very noticeable. A performer entrusted with such a part must, therefore, be either a pianist or an organist. For detailed exercises, appropriate to seraphine playing, the student is referred to studies written for the organ or pianoforte.

DULCITONE

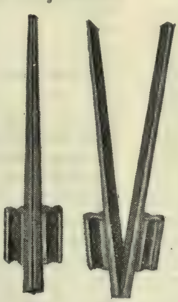


DULCITONE [Machell]

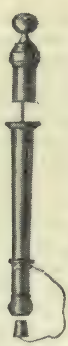
Instead of steel rods, this ingenious instrument contains rows of tuning forks struck by felt-covered hammers, damped by felted levers. After the instrument once leaves the maker, no tuning is therefore required. The compass is from three and a half to five octaves, and the weight is from 25 lb. The dulcitone has been used with marked success as a substitute in the orchestra for distant bells, or in conjunction with the church organ for echo effects. In ballet music, also, it has been heard with advantage. In quality, the tone is pure, sweet, and carries well. As the price is moderate and the instrument takes up but small space, it serves as an excellent substitute in house boats, yachts, and elsewhere if room is a consideration.

CASTANETS & TAMBOURINES

In the modern ballet orchestra, indispensable features of gipsy, Spanish, or Neapolitan dance music are parts for these percussion instruments. When, in so-called programme music, the composer endeavours to portray unusually realistic effects, the side-drummer has to be provided with a number of strange contrivances. It is to him that the manipulation of such accessories is allotted, especially in open-air band performances. In pieces descriptive of a hunt, etc., he needs a pair of wooden clappers to imitate the sounds of a whip. The orchestral whip costs about 6s.



Shut Open
WOODEN CLAPPERS



POP-GUN [Mahillon]

Haydn, Romberg, Mendelssohn, and other masters in their burlesque or toy symphonies, make use, further, of the sounds of various bird-calls and the pop-gun. The latter, in descriptive military band arrangements, occasionally necessitates the side-drummer being provided with a band pop-gun. This costs about 6s., and its noise is sometimes effective.

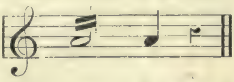
Tambourines. The chief of the side-drummer's accessories are the tambourine and castanets. For military bands, the tambourine is 15 in. in diameter, and costs about 18s. The

orchestral model is slightly smaller. "Tambour," or drum, gave this instrument its name. It consists of a single drum-head, or parchment skin, stretched over a circular rim. The depth of the latter reinforces the sound. Small rods are fitted in the rim. To tighten or slacken the vibrating surface, screw the fly-nuts up or down. Cut out in the rim are a number of slots. In these slots miniature cymbals are arranged loosely in pairs. These impart to the tone much of its distinctive effect.

Tambourine music as an orchestral accompaniment to the tarantella or any Oriental dance, is written in the treble clef, usually on A, second space, being marked in the side-drum part. Although this instrument is a species of drum, it is not hit with a stick. Both hands of the player are required for its manipulation. It is capable of a variety of effects. When simply struck by the hand by a body of dancers, the peculiar noise it gives is most distinctive. If it be played by a single performer, one hand usually causes it to vibrate, so that the small cymbals jingle, whilst it is struck by, or strikes, the fist or tips of the fingers of the other hand. Berlioz has made considerable use of tambourine effects. A favourite direction of his was to get the curious tremolo, or roll, which is obtained by rubbing the tambourine-head with one of the fingers of the hand, not holding it. In that case, the noises of the small bells in the rim are chiefly audible.

MILITARY TAMBOURINE

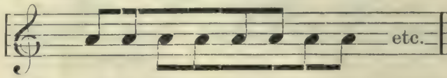
Such a roll is indicated as here shown. It is usually very short, because the finger rubbing the parchment causes the sound to cease as the digit approaches the margin of the rim. In music portraying a masquerade, or other extravaganza, a weird rumbling is caused by rubbing the vellum with the full strength of the thumb. By spinning the instrument on the finger-tips, expert players get other varieties of sound from the tambourine.



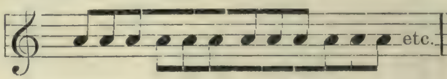
Castanets. In ballet music, when Spanish or Oriental dances are introduced, inseparable from the tambourine are the castanets. "Castaneta" is the Spanish for chestnuts. Ever since the Moors introduced into the South of Europe certain characteristic dances it has been the custom for the performers to attach to each hand small cups of hard wood or ivory, joined together by a string, and shaped like the two sides of a chestnut. If these adjuncts are not available, the clicking effects they produce are imitated by the dancers drawing the fingers quickly, from the point to the ball of each thumb. Most Spaniards are experts in this accomplishment, but in a ballet, if the dancers use castanets, they are fitted to the fingers. One little clapper is fastened to the thumb, the other is attached to the middle finger. To emphasise the rhythm of the dance, the two are then struck together.

But there is a vast difference between merely clicking the castanets and playing them expertly. Accomplished performers are able to get a neat roll on them of several bars' duration. To do this requires careful practice. The student who desires to be able to articulate distinctly the different rhythms indicated in the ballets of Bizet, Delibes, to say nothing of those of Wenzel, Jacobi, or Byng, should begin by single-stroke exercises with alternate hands.

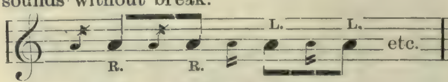
Here the object is to make each beat with the utmost regularity, and the student is advised to practise with the metronome in slow time at first, and increase the speed gradually until the semblance of a roll is obtained. Having acquired facility to make a single sound with each hand, try double sounds in the same way.



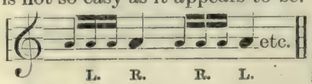
The next problem is to get distinct triplets by the hand, without any break or hesitation in the sequence of the sounds, so that each stroke should be of equal force.



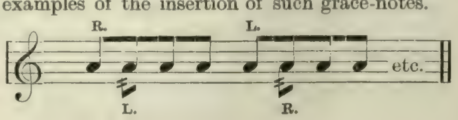
Grace-notes. As the castanets are embellishments in themselves to the effect of the dance, their performance is pleasantly varied by making short clicks or grace-notes mingle with those which are more emphasised. First, endeavour to produce a short click preceding a loud one, so that the right hand gives two postman's "rat-tats," and the left hand echoes those sounds without break.



The student should next endeavour to make with one hand a quick triplet softly and finish it by a loud stroke with the other hand. This is not so easy as it appears to be.



In side-drum playing, three grace-notes together are known as a "full drag." It must not be forgotten that in dancing the time-stroke usually falls when the point of the toe touches the ground, and that stroke should be emphasised. But during turning movements, pirouettes, or bendings, the castanets are particularly effective when they execute a number of short grace-notes together. These are, in a solo dance, inserted according to the fancy of the artist. But if they are to be a true embellishment, the castanets should be practised apart from the dance. We give in conclusion, one of the most ordinary examples of the insertion of such grace-notes.



Here it will be observed that the right and left hands alternately make four clicks in strict time. But on the second beat in each quadruplet the opposite hand inserts three or more short notes to embellish the rhythm. In the seguidilla and other lively dances, the castanet-player who can do this neatly finds that the time spent in study is well rewarded.

But when castanet music appears in a side-drummer's part he has no time, as a rule, to fit the apparatus to his fingers. Therefore, the orchestral or military performer provides himself with a pair of castanets attached to a handle about 1 ft. long. Between the two little cups is the stationary bowl of a wooden spoon, so that, when the handle is shaken, the castanets strike against this bowl. The player can thus at any moment insert castanet effects without difficulty. Sometimes in military bands a pair of castanets, held open by light springs, is attached to the hoop of the side-drum, and is manipulated by the drumstick. Orchestral castanets cost about 4s. The more familiar nigger minstrels' "bones" are but enlarged editions of the classical castanet, which goes back to the days of Babylonia and Assyria.

BELL-RINGING

Between the music of Art and that of Nature, bells are regarded as the connecting link. Being of fixed tone, they have been occasionally employed for impressive orchestral effects by Auber, Rossini, Donizetti, Meyerbeer, Sullivan, Wagner, and other great composers. Yet, in an artistic sense, bells are incapable of musical use in their truest form, since their full sounds can only be elicited when they are swung and hit by a clapper. But this precludes timing the exact moment of striking as well as the precise degree of force for each blow. It is, however, the irregular and formless character of the tones produced even by the best change-ringers which imparts that wild mystery or uncertainty to the sound of bells so attractive in the open country.

Of bell-ringing, the chief kinds are handbell-ringing, steeple-ringing, and tower-carillons.

Handbells. Nearly every church possessing a peal of bells keeps a miniature set for training beginners before they are allowed into the steeple. Though somewhat similar in appearance to the railway handbell, the tone is differently controlled. Instead of the clapper swinging loosely, it is supported by springs. These keep the tongue from touching the bell-lip when held horizontally. Yet, when the bell is required to be struck, the springs offer the least possible resistance. Moreover, the tongue, instead of being of metal, is of thick felt weighted to give the necessary force. Instead of being harsh, the tone produced by this means is sonorous and sweet, allowing the harmonics to be heard pleasantly. A peal of eight handbells, properly tuned, can be procured from any bell-founder for from £4 to £5. With these small editions of the large steeple-bells, the intricacies of ringing can be learnt without annoyance to a neighbourhood. For ordinary changes, five bells suffice. Few towers contain more than this number.

The students should seat themselves in a semicircle, so that each can see the other without having to turn round. On the extreme right of the semicircle is seated the first treble—generally the youngest performer—he having the smallest bell. At the extreme left point sits the physically strongest man with the largest bell, known as the bass. In the centre of the semicircle is the alto. In advance of him, on the right, is the second treble, and on the left of the alto is the tenor. In front is the conductor. Instruction starts by each student being taught how to sound his bell properly.

Correct Position of Hand and Bell. Grasp the bell by the handle. Hold it downwards to represent the position of the bell as it hangs in the steeple. The leather handle, here, is flat, and the clapper is so hinged that it will only swing towards the flat sides of the handle. If held flat-side uppermost and waved from right to left, or left to right, it will not strike. Only upward or downward motions cause it to sound. In grasping the handle the thumb, pointing downwards, should press the brass rivet in the flat side towards the body of the ringer. Turn the back of the hand to the left, so that the fingers are round the flat side of the handle away from the body. Now, sloping the handle slightly downwards, the clapper will fall by its own weight opposite the side it is to strike. The spring prevents the tongue touching the lip of the bell.

The "ring" is given by turning the hand half round to the right. To ensure the strike, all that is needed is a slight impetus from the wrist. The first motion is to get a blow with the bell upwards. Raise the bell towards the shoulder, giving a slight jerk to represent a "hand stroke" in the steeple. The next motion is downwards towards the knee, to represent the "back stroke."

Rounds. The most common use to which a peal is put is that of ringing "rounds." On the Continent, besides pulling bells singly or clashing them together, campanology is unknown, despite the praises Schiller and many other foreign poets have lavished on the ringing of bells. In Great Britain, however, if there are five bells, they are tuned diatonically, and range, in position of rounds, numerically from the smallest to the biggest. The first treble, therefore, is "No. 1," the second treble "No. 2," the alto "3," the tenor "4" and the bass "5." In round-ringing the art is for each bell to strike with the utmost regularity. The custom is for each ringer to start off with a hand stroke, continuing without pause, each with a back stroke. When changing, in the third round, from "back" to "hand," there is a slight pause, as if, after counting five, came the figure "0." Two rounds are then played without break, the completion of the whole "pull" being marked by a second pause, and so on with a rest after every two rounds or whole pull. Consequently, if the ringing is in four-four time, the effect, at the beginning, puts the accent on the "lead," given by the first treble. The fifth bell, being the bass, the accent on the next bar is transferred to the lowest note. This is immediately followed,

without break of time, by the three upper bells, so the third bar gets its accent from the tenor. This is followed by the bass bell to complete the back stroke. On the third beat of the bar there is a pause, and the first treble, beginning on the fourth of the bar, the accent on the fifth bar is given by the second treble. The smallest bell thus starts the sixth bar. But, as a back stroke is given, the tone is different in character to when that bell started off with the hand stroke.

The next bar is begun by the bass to finish the back stroke, and complete the whole pull. In the sixth bar, a rest thus occurs on the second beat. So the two treble bells mark the "three"—"four," and the accent on the seventh bar is made by the alto, and on the eighth bar by the second treble with the back stroke. Although only five notes are repeated in the same sequence, owing to the different accents and strokes considerable variety is accomplished in good round-ringing. [Ex. **1**.]

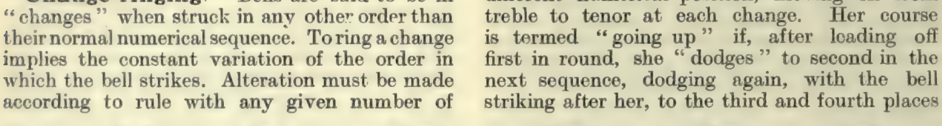
By altering four-four into three-four time, on the word "Go" from the conductor treble leads with a hand stroke as before. But the tenor, as his bell is fourth, puts the accent on the second bar. The fifth and first bells having struck, the accent on the third bar is transferred to the second treble, and the bass emphasises the first beat of the fourth bar. Pause on the second beat. The third beat is thus given by the "lead," and the fifth bar has the hand-stroke accent from the second treble, while the same accent by the bass starts the sixth bar, the alto emphasising the seventh. On the first beat of the eighth bar there is a pause ; on the ninth, the accent is given by the alto with a hand stroke, the treble starting the tenth with a back stroke, the eleventh bar being accented in the same way by the tenor. [Ex. **2**.]

Change-ringing. Bells are said to be in "changes" when struck in any other order than their normal numerical sequence. To ring a change implies the constant variation of the order in which the bell strikes. Alteration must be made according to rule with any given number of bells, so that they work observing the correct formula. If there are four bells, 24 changes is the limit, and the time occupied is one minute. If there are five, 120 changes is the number, these taking five minutes. With six bells there are 720 changes, occupying half an hour. With seven, upwards of 5,000 take three hours This is called a "peal." Shorter changes may be designated a "flourish" or "touch." With eight, upwards of 40,000 changes require a day and four hours. Nine bells give more than 360,000 changes, occupying ten days and twelve hours. When we come to twelve bells, the changes run into millions. In an early stage of the art, therefore, five bells with 120 changes suffice for any student. No change is complete until every variation of which the peal is capable is produced. The bells are then brought back into rounds. Like a ship, a bell is of feminine gender. She is never referred to by a bellringer as "it," but always as "she" or "her."

"Dodging." After rounds, the student must understand how to "dodge," either with the bell before or after him. If he has treble, and is told to "dodge," on the word "Go" he leads off with a round, first with a hand stroke and then a back stroke. Then comes a pause for No. 2 to ring first, No. 1 taking his proper place with the back-stroke round. He strikes second in the sequence which follows, and first again on the word "Round" from the conductor. If he is put to the third bell and is told to "dodge with second," on the word "Go," a hand and back stroke round being rung, in the third sequence he will strike in No. 2's place, the latter following him. In the fourth sequence, he strikes in his own place, dodging again in the fifth sequence. On "Round" being called, he returns to his normal order.

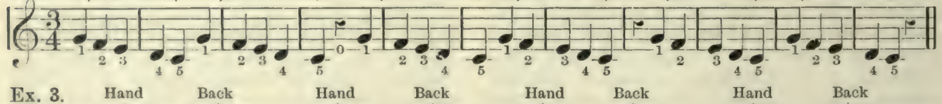
A bell goes "up" when she strikes in a different numerical position, moving on from treble to tenor at each change. Her course is termed "going up" if, after leading off first in round, she "dodges" to second in the next sequence, dodging again, with the bell striking after her, to the third and fourth places

Ex. **1**.

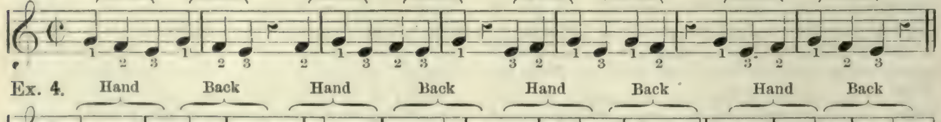


Ex. **2**.

Ex. **3**.



Ex. **4**.



Ex. 5.

in the next two changes. On the other hand, her course is called "going down" if she alters her position from behind to the front. In the steeple, the expression refers to holding "up" the bell herself, when she must be rung slower to allow the others to strike before her. Likewise, if she is returning to "lead," she must be struck more quickly, or "rung lower." In other words, she then goes "down."

"Hunting." Hunting is carried out in two ways—"hunting up" and "hunting down." The first means striking after the bell last pulled, and is applicable to any number of bells. If three are being rung, and the student is first treble, on the word "Go" second treble will strike after him. In the first change, he must, therefore, pull after No. 2. The sequence thus is 2 1 3. Keeping his eye on No. 3, No. 1 will next strike after her. The order will then be 2 3 1. This brings No. 1 behind. On arriving in that position, the rule is to strike in the same place in the next change. So the sequence following becomes 3 2 1. Having "hunted up," No. 1 must now "hunt down." To do this, he has to look for the bell which strikes first of the other two. This is No. 3. Ringing after her, the sequence becomes 3 1 2. He is thus brought into No. 2's place. In the next change, he leads. The sequence is 1 3 2. As the rule, on returning to "lead," is to strike twice, in the next change the order of the bells is normal. They are, therefore, brought back to rounds, having performed the full six changes possible by three bells. [Ex 3.]

Hunting with Five Bells. Instead of three handbells, try five. If the student has first treble, and watches his four companions, he will soon get into the way of sounding his bell at the correct moment. At the first change he will strike into No. 2's place by ringing after the bell which followed him. If the sequence was 1 4 5 3 2, it will now be 4 1 3 5 2. Therefore, No. 1 bell will now be "below," and No. 3 "above" him. He must observe the latter to note which one follows him. Next time, he must "pull" after that one. In other words, he changes his sound-place with No. 3. The sequence rung becomes 4 3 1 2 5. Striking now in the centre place, he will have two bells "below," and two "above." Keeping an eye on the latter, he strikes his next blow after the bell which follows him. The sequence is, thus, 3 4 2 1 5. Having taken No. 4's place, there are three bells "below," so that he has only one to note. Striking after this next time, the change becomes 3 2 4 5 1. This makes his first stroke "behind." Having four bells "below," he must strike after the last of them. This will be No. 1's ultimate stroke "behind." Reversing the process, he will hunt down the other four bells. He lets the last number he pulled after pass him, so that he descends into No. 4's place. Striking after the last of the three below him, he next rings in No. 3's place, and, in due course, No. 2's, till he gets back to "lead." He will then strike again in the next sequence, and continue to hunt up and down till rounds are called.

The Course Method. Many ringers consider the "course" plan easier for hunting down than that described. All the student has now to remark is the bell which he "turns from behind," or that after which he has next to ring. When he has struck after her his first blow behind, she becomes his "course" down to lead. Supposing the student is No 2, and the sequence is 1 5 4 2 3. In hunting up, No. 2 turns No. 3 "from behind." So the first blow No. 2 strikes behind makes the sequence 1 4 5 3 2. According to rule, in the next half round No. 2 must strike behind again. But the ringer watches No. 3, that bell having moved down one, giving the sequence 4 1 3 5 2. The fifth, therefore, comes between 2 and 3. In the next change, as No. 1 is hunting up, she will intervene. No matter what bell follows No. 3, No. 2 follows that bell. The sequence thus becomes 4 3 1 2 5. In the next change, she moves down one into No. 3's place, No. 3 now being at "lead," the sequence making 3 4 2 1 5. As No. 3 has to give a second blow in the same place, No. 2 now gets close to her "course." So the sequence is 3 2 4 5 1. In the next change, therefore, No. 2 gives the first blow. The result of this hunting down by "course" method sounds as in Ex. 4.

Place-making. When a bell arrives "behind" or at "lead" in hunting, we have seen that she must strike two blows in each successive half round, so that she "lies a whole pull" in the same position. Yet, if this lying a whole pull

were made uniformly, the possibilities of variation could not be fully developed. It is necessary, therefore, for other bells sometimes to "make a place" in the same way in one of the inner positions by striking two blows in succession at the same point. Thus, if No. 5 follows No. 1 in the first half-pull, and is cautioned to "make a place" in the second half-pull, she will again follow lead. Hence, she also will lie a whole pull next to treble. Meanwhile, No. 4 has been told to make place at No. 3. Thus, while No. 5 goes down to lead, No. 4 makes a second blow in No. 3's place, lying a whole pull in that position, as will here be seen:

1 5 3 4 2
1 5 4 3 2
5 1 4 2 3
5 4 1 3 2

To make all the alterations of which four bells are capable necessitates a knowledge of further rules. Here the changes are divided into three sets of eight each. On the word "Go" rounds are rung till the ringers get steady. Bells 1 and 3 then start hunting up, whilst 2 and 4 proceed to hunt down. Each bell lies a whole pull on arriving at "lead" or "behind." By "plain hunting," the eight changes produced are these:

2 1 4 3
2 4 1 3
4 2 3 1
4 3 2 1
3 4 1 2
3 1 4 2
1 3 2 4
1 3 4 2

The bottom line introduces a new rule. If the plain hunting were continued, No. 4, on arriving behind, would strike twice, and No. 3 proceed to third place, while No. 2 would descend to second place. With that method, however, the result would be a normal round. This should not occur until the whole change is rung. To produce the twenty-four variations, the rule is that "the bell treble takes from 'lead,' makes second place and leads again, the other bells dodging at back stroke-lead of treble." The ringing is thus given a fresh lease of plain hunting:

3 1 2 4
3 2 1 4
2 3 4 1
2 4 3 1
4 2 1 3
4 1 2 3
1 4 3 2
1 4 2 3

Here we see Nos. 3 and 1 are hunting up, while Nos. 2 and 4 hunt down, each bell striking twice on arriving at lead, or behind, except in the back stroke of the last pull, where the bell treble takes from lead, makes second place, and leads again, the others meanwhile dodging at the back stroke lead of treble. Consequently, Nos. 4 and 1 now hunt up, while Nos. 3 and 2 hunt down, until the change is completed thus:

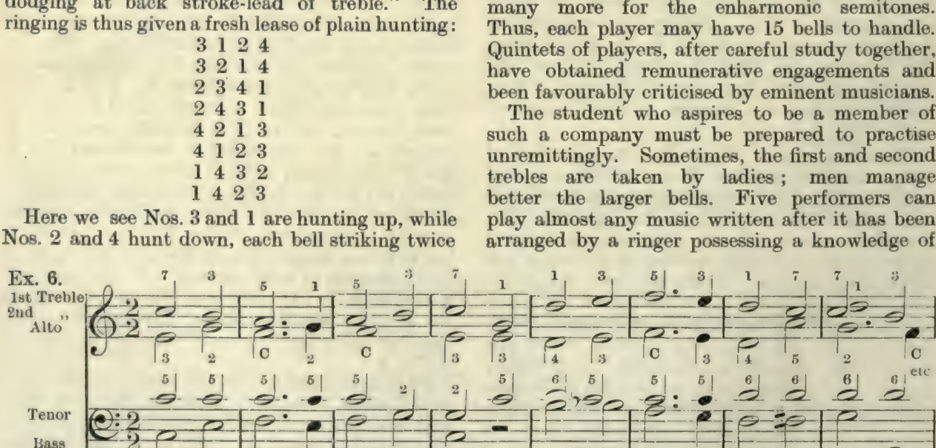
4 1 3 2
4 3 1 2
3 4 2 1
3 2 4 1
2 3 1 4
2 1 3 4
1 2 4 3
1 2 3 4

The students should now try Ex. 5.

Practising with Two Bells. The foregoing changes can be learnt by two players with handbells facing each other. One student should take 1 and 3, the other working 2 and 4. Although, in the steeple, the vibrations continue, when practising with miniatures the tone should be damped. For this purpose, double up a blanket, or thick rug, and spread it over a table between the players. Each bell is then taken up and replaced on every stroke so that no two sound together. If this is done in correct time, the effect will be *legato*. Should the damping be premature the sounds will be *staccato*. The same students can work a peal of eight bells by playing two with each hand. If attention is confined to change-ringing endless variations can be studied. Yet, however fascinating this may be in a steeple, it is not so entertaining to the uninitiated home circle. It is well, therefore, to practise diatonic melodies within the compass of one octave, as the eight bells generally represent the scale. Such exercises are useful discipline in keeping correct time. Handbell ringing by five performers has been made charmingly effective throughout a compass of five octaves including sharps and flats, different bells being used for the sharps to those for the flats. This accuracy in tuning entails 36 bells for the diatonic notes and as many more for the enharmonic semitones. Thus, each player may have 15 bells to handle. Quintets of players, after careful study together, have obtained remunerative engagements and been favourably criticised by eminent musicians.

The student who aspires to be a member of such a company must be prepared to practise unremittingly. Sometimes, the first and second trebles are taken by ladies; men manage better the larger bells. Five performers can play almost any music written after it has been arranged by a ringer possessing a knowledge of

Ex. 6.



harmony and composition. This is not so if there are only four performers. The rapid work in the upper voice is often more than one ringer can accomplish satisfactorily.

The Table. The student must be a good timist. Experience shows that the dimensions of a handbell table are most convenient when it is 16 ft. long by 7 ft. wide. To a depth of 3½ ft. from the front, the left end is reserved for the bass player's bells. At the far right end of the table towards the front (where the audience would be) is the place of the first treble, with 3½ ft. space before him for the smaller instruments. The long side, beyond the portion reserved for the bass, is divided with the second treble on the right, the alto on his left, and the tenor on the left of the alto, together with 3½ ft. in front of each of them for the bells most frequently required. That area of the table beyond these five divisions is used for depositing bells not wanted during the performance of a piece. If, for instance, the melody is in G, the C♭ bells are not likely to be required. As all pieces must be memorised before a public performance, players soon know the bells they need for any item.

Stand to play, and do not waste energy by flourishing about a bell except when a long, sustained note is required. Each instrument has a definite position in its compartment before the player. The one on his extreme left and in the row closest to him is always known as No. 1, the left bell of the second row being No. 2. On the right of No. 1 come Nos. 3, 5, 7, 9 ; while on the right of No. 2 come Nos. 4, 6, 8 and "0." Thus, the nearest row consists of odd numbers and the second of even. Those in the third row, beginning at the left, are called A, B, C, D and E. These letters designate the positions on the table. They do not refer to the notes of the bells.

The Science of Bellringing. Ringers calculate by position. Pythagoras regarded music as the "Science of numbers." To-day bellringing is taught and practised by mathematical rather than aural notation. Unless the faculty of counting is cultivated the student cannot hope to excel. Before attempting to handle a number of bells, begin by practising with not more than four. Place these in their proper order. Ring all the changes on the four bells until facility in that exercise is acquired. Then add two more to the right and study the six changes. Afterwards add bells in places A and B. Finally, as progress is made, 7, 8, 9, 0 and C, D and E can be employed. It will be found that two right-hand bells frequently follow each other quickly. In that case, the first, after being struck, must be transferred quickly to the left hand. If this is otherwise occupied, both bells can be held in one hand. Instead of taking the first bell between the thumb and first finger, lift it by the second and first.

The second bell can then be taken up by the thumb and first finger. But it must be held with its handle at right angles to the first. With the flat side towards the player's body the first bell can be rung either by an upward or downward movement without the other sounding. When No. 2 should ring, a turn of the wrist will bring the flat of its handle towards the player. The clapper will then strike without a second blow being given by the first bell. Taking two bells in each hand for consecutive notes, the student should practise the scale slowly until facility in this useful method of manipulation is obtained. It is only by such means that accomplished handbell ringers can acquire mastery over fifty or more bells.

Quintet Music. For a quintet such as described, the music is written in five staves. That for the two trebles and the alto is in the treble clef, and that for the tenor and bass in the bass clef. To save space we indicate on two staves the opening bars of Costa's "March of the Israelites," marking the positions for each bell [**6**]. Notes for the first treble are indicated by the tails being turned up, while the tails are turned down for the second. These performers divide the treble work ; they do not double it. It will be observed that the C and D are sounded together in bar 7. In this case, the first treble takes the C and the second the D ; but in bellringing the effect is always better when sounds are arpeggioed rather than struck in chords.

To get the numbers and letters correctly, when deciphering handbell notation the student must make out a plan for himself for the arrangement of the bells in his own compartment. These, being not in the same order as the sounds are represented on a piano keyboard, may appear confusing at first. They are located rather after the method of the letters on a typewriting machine, bells most frequently wanted being placed most conveniently for the two hands. Thus, as the example given is in the key of C, both C bells are on the right of the first treble's compartment. The G, or dominant, being next frequently wanted, is placed on his extreme left. The A's, giving an interval of a third, come next to the C's, while the B's are on the right of the G. As G♯ is only needed once in the piece it is placed by itself in the third row in position A.

As the second treble divides work with the first, the bell this player will use most is the octave G above that allotted to the first treble. So this G is on the second's right. On his left is the D, and on its right the E, the F being on the left of G. In the third row, in the positions A, B and C, are the bells giving B♭, C♯, and D♯, they being only seldom needed.

Steeple Ringing. After practising the rudiments with the handbells, the student should ascend a belfry. In her ordinary position in the tower, the bell hangs downwards. When swung and struck, her hollow body emits—according to the diameter of the mouth, thickness of sound bow, height, and other proportions—several tones. These are the "Strike" note, "Hum" note, the "Nominal," a minor third and perfect fifth in the first octave. and a major third and perfect fifth in the second octave. When the bell is in tune with herself, the "Hum" tone should sound a perfect octave below the "Strike" note, which gives the pitch.

The harmonics of a bell differ from those elicited from any string or wind instrument. Each sound is regarded as a principal tone dependent on the various curves of the bell. The "Hum" note, therefore, does not follow the law of resultant tones, and the presence of the lower minor and the upper major thirds is a puzzle which, so far, has baffled the greatest acousticians. In very large bells one hears—provided she is in tune with herself—a glorious succession of octave harmonics which have a peculiar charm. It is probably owing to the presence of so many sounds that bellringers refer to "Key" rather than the note which each instrument in a peal represents.

How the Bells are Fixed. On the top of the bell, cast with her, are two rings or "cannons." Iron braces, strongly bolted, secure these cannons to the cross-beam or "stock." To this, at one end, is fitted the iron axle into what are called "gudgeons." The axle works on brass or gun-metal bearings, to prevent corrosion. On one side of the stock is fitted a broad spoke of a wheel, in diameter more than double the height of the bell, the wheel working on an axle similar to that on the opposite side.

Both axles rest on stout beams firmly bolted to the floor of the bell-tower, forming together the timber cage for the bell, shaped like three sides of an oblong. The tire of the wheel is grooved. Attached to the large spoke, the bell-rope passes through an eye in the tire. Thence, it goes along the groove, down over the wheel and through the floor over a pulley, so that it works easily, into the belfry below. The ringers thus have the floor between them and the bell. So they are neither deafened by the strongest sounds of a peal nor exposed to inclemencies of the open air. When the rope is pulled at a distance of, say, 3 ft., if the bell is that height, the result is that her mouth, instead of pointing down, is thrown skyward. The ball of the clapper, striking that portion of the lip immediately over the head of the ringer, gives the hand stroke. On the rope being released the distance of the diameter of the mouth, the flight of the clapper hits the lip in the opposite direction away from the ringer. This is the back stroke. No matter how hard the bell is pulled, she cannot make a complete revolution. The beam on which she is hung is checked by an iron stay, the flight of the clapper being restrained by a relapsing curved rod known as the "slider." A forward and backward stroke of the bell constitute a whole pull. The student should practise with the bell lashed.

Practice in the Belfry. Take a piece of fine rope and make a noose in the centre big enough to slip over the flight of the clapper; the ends must pass over the lip of a bell on either side. Protect the lash at those points with leather, to prevent cutting. Make the rope fast to the cannons at the top of the bell. When she is now pulled, there will be no tone. A bellringer, who acts as coach, should set her at back stroke. He will adjust the rope to the exact length required by the student. Below the "sallie," or plumed wrapping, a bell rope is half as long again as is likely to be needed for the shortest ringer. When at back stroke, the rope should terminate in a loop just above the student's head. If it is too high, he cannot grasp it easily. The "tuckings," in that case, must be laid down; otherwise, they are pulled up by coiling, spiral fashion, to the right point, as needed.

Having set the back stroke, the coach should place the bell at hand stroke. The student, stretching his arms to their full extent without straining, should now be able to grasp the "sallie," or tufted part. Pull the rope down carefully till the bell is brought to balance at the hand stroke. If her weight is under 10 cwt., a force of 2 lb. or 3 lb. will bring her over the balance. As soon as she is "off," put the hand not holding the end of the rope down to that end. At the back stroke let the bell carry up both hands till she is just off her balance again. Stop her there, so that she does not hit the check. Pull her "off" with the same force as at hand stroke. When the "sallie" is opposite the student's face, he must grasp it, first with one hand, and then the other. He should let the bell carry his hands up to back stroke till she is again over the balance, without allowing the "sallie" to slip through the hand. To let the rope slide is a bad habit.

Attitude. Stand upright. Do not bend the body from the hips. Unless the student stands properly, the necessary coil of rope is apt to get into his face, and perhaps round his neck. If a large bell requires strength, drop the knees slightly. The mechanism probably needs attention if she requires more than 6 lb. weight to pull her off. Keep one foot slightly in advance of the other. When a position is once taken up, adhere to it till the completion of a flourish or peal. Do not turn the whole body in looking from one rope to another. Such a habit is exhausting when a 5,000 change is rung. A turn of the eyes or head will suffice. Having mastered a lashed bell, the student may take No. 3 in rounds. He must then listen for the interval between the strokes preceding him. If No. 1 in rounds, he must allow double time after completion of the back strokes before starting off again with hand strokes.

Carillons. In contrast to the irregular effect produced by change-ringing when bells are swung, a carillon implies a greater number of bells set close together and hung dead. Enclosed in a frame, a peal, like that at Bruges or Ghent, includes 48 bells. These are struck like clocks, mechanically, by a hammer on the outside of the lip.

INSTRUMENTS *concluded; followed by* ORCHESTRATION

PRESERVING THE FORESHORE

Considerations in Protective Sea Works. Different Types of Protective Works. Groynes and Stock-Ramming. Piers

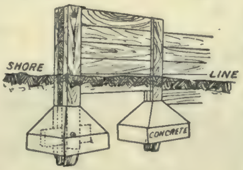
continued from page 5487

By Professor HENRY ROBINSON

THE prevention of damage to and loss of valuable land by the constant action of the waves on the foreshores is one of national importance. At the present time there is absolutely no official and reliable record of the changes annually taking place round our coasts, and these changes are constantly affecting buildings and other works which have been carried out at a large outlay of public money. The annual loss of land in some parts of the country has been recorded, the following being a few examples which were given in a paper read before the Institution of Civil Engineers. The annual loss of land on the East Coast alone represents an area somewhat larger than the island of Heligoland.

Withernsea	..	6 yds. per ann.
Dimlington	..	3½ ,, ,,
Easington	..	5 ,, ,,
Mappleton	..	2 to 3 ,, ,,
Hornsea Burton		2½ to 4½ ,, ,,
Aldborough	..	2 to 2½ ,, ,,

19. CASE'S ELLIPTICAL THEORY

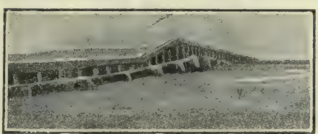


20. CASE GROYNE

It is proposed, in this article, to consider generally the circumstances under which the loss of land occurs, and, although no rules can be laid down, to describe some of the methods employed under different circumstances for protecting foreshores from erosion.

The erosion of the coast-line is a subject which offers a wide field for investigation, which is being made by a Royal Commission. The subsidence of the land also deserves consideration.

Dr. Geikie remarks in his textbook on geology: "It is difficult to trace a downward movement of land, for the evidence of each successive sea margin is carried down and washed away or covered up. In the great majority of cases where such an advance is taking place, it is due, not to subsidence of land, but to erosion of the shores. The results of mere erosion by the sea, however, and those of actual depression of the level of the land cannot always be distinguished without some care. The encroachment of the sea upon the land may involve the disappearance of successive fields, roads, houses, and villages, and even whole parishes without any actual change of the level of the land."



21. BEARD'S GROYNE

Erosion is due to several causes, the chief being the scouring action of the sea on the foreshore, which is sometimes assisted by the action of rain and frost on the cliff face.

The erosion of the bed of the sea in most cases is impossible to remedy. It is due to the action of tidal and other currents and sometimes to submarine fresh-water springs.

Points for Observation. The following are the most important points to be observed when considering the protection of foreshores:

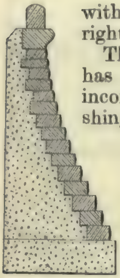
1. Range of tide.
2. Direction and intensity of prevalent winds.
3. Direction and intensity of destructive winds.
4. Direction and force of 'long-shore currents, surface and bottom velocities being taken at high water, mean tide, and low water.
5. Percentage of material, per cubic foot or yard of water, carried in suspension. Samples to be taken from surface and close to the bottom.
6. Quantity of shingle or other detritus, and extent to which it is moved during different conditions of wind, waves, tide, etc.
7. Nature and depth of the marl, sandstone, or other material undergoing erosion.
8. Extent to which the sea bottom is undergoing change, especially in the matter of the formation or alteration of submerged banks causing alterations in the directions of currents.
9. Nature of material thrown on shore during on-shore gales, and the depth of water from which the material is torn.

The encroachment of the sea upon the land is a source of great anxiety to owners of sea frontages. In many cases where the land is used for agricultural purposes the pecuniary loss is insignificant as compared to the cost of protective works and the maintenance of them. This is, however, different when the land is valuable, and is required for building purposes. Then the construction of sea walls justifies the expense by affording protection to the valuable property behind them.

Protective Works. In many cases the expense of protective works falls on the owner of the frontage, as those owning the land immediately behind may be indifferent and prepared to wait until their turn arrives. This is obviously unsatisfactory, and as the whole question is a national one, some sort of Government aid and control is necessary. Land once lost to the sea, in many cases, cannot be reclaimed

without involving questions of foreshore rights.

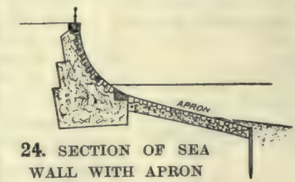
The action of a wave on a foreshore has two distinct results, that of the incoming water driving the sand and shingle up the beach, and, as the water retires, drawing the sand and shingle back into deep water. This material (or travelling beach) is deflected seawards, and is carried elsewhere, forming sandbanks and shoals. The place of deposition of the eroded matter is difficult to locate, as it is sometimes carried in suspension great distances. The arresting and depositing of this travelling beach is attained by groynes, properly arranged and constructed, whereby the beach level is raised.



22. SECTION OF SEA WALL

23. SECTION OF SEA WALL WITH APRON

Groynes should be constructed in such a manner as to direct the power of the sea in depositing the drifting sand or shingle where it is needed, and to retain it in position. In this manner the beach level and foreshore are gradually raised. To assure this result a thorough knowledge of the tides, etc., on the coast under consideration must be obtained in order to settle the position, number, and distance apart of the groynes, which should be carried down to low-water mark if practicable. The construction and strength of the groynes must depend on the locality, and on the conditions which they will be required to fulfil. The ultimate height to which the groyne is to be carried must be provided for. The full height, however, should not be planked immediately, as it would expose a large surface to the full force of the waves, but it should be raised as the sand or shingle accumulates at the groyne. It is a matter of opinion as to the angle at which the groynes should be placed, but the writer does not agree with the assumption of many that all groynes should be placed at right angles to the shore. Unless the groyne is placed at the correct angle the shingle will be found to collect on the windward side and not on the leeward, causing a drop, in some cases of many feet, thus weakening the groyne and disfiguring the beach, while no protection is given to the coastline on the leeward side of the groyne.



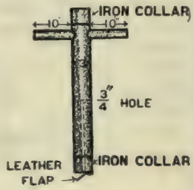
24. SECTION OF SEA WALL WITH APRON

Different Types of Groynes. The late Mr. Edward Case considered that the correct form of any shore composed of beach, sand, or any other shiftable material was a gradually sloping surface, the section of such shore between high and low water marks being an ellipse, the construction of which depended upon the range of tide and the horizontal distance between high and low water marks.

According to this elliptic theory, the shore should follow the curve *e e e e* from the point A upwards [19] and, if suitable material can be introduced, and this curve be arrived at, the sea should do no further damage, but should roll harmlessly in and out.

To obtain this result Mr. Case placed groynes constructed of light timber [20] between low-water mark and mean sea-level, and normal to the curve of low-water line, in order to trap the travelling beach. This system of groyning has been successfully employed at various places.

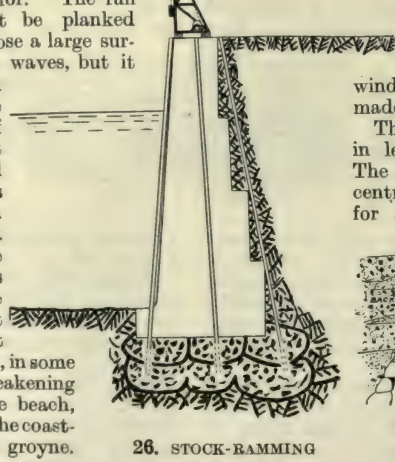
Another system of groynes is that invented by Mr. E. T. Beard, and is known as *Beard's Contour System* of groynes. This system has been employed at several places with success, notably at Cooding, Bexhill, in Sussex, where Mr. Beard informed the writer, in January, 1906, that the high-water mark has been driven 120 ft. seawards, and the beach level had been raised 19 ft. The special feature of this system is the *ramp* which divides the groyne into two portions as shown by **21**, the upper one to retain the permanent beach and the lower one to permit the drift to pass freely over the groyne.



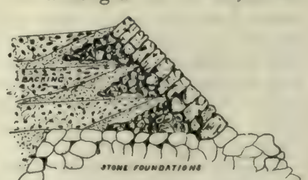
25. STOCK-RAMMER

At Cooding the groynes were required to protect land lying behind a narrow shingle bank in which breaches had been made by the sea, the level of the land being below high-water mark. The length of these groynes was 328 ft. spaced at the rate of eight to the mile. The angle that the windward side of the groynes made with the shore was obtuse.

The piles, or uprights, varied in length from 10 ft. to 25 ft. The longest is placed at the central portion of the groyne for a length of 60 ft., where

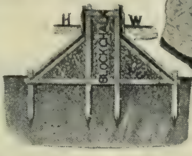


26. STOCK-RAMMING

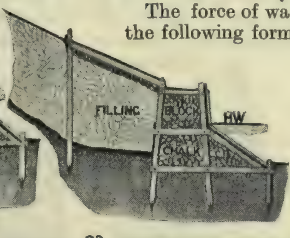


27. RUBBLE WALL FOR PROTECTING BANKS

the greatest force of the sea was expected. These long piles were also bedded in concrete, and were provided with land ties placed in two tiers one above the other and bolted to a main pile and between a pair of walings, 6 in. by 9 in. These ties were all placed on the windward side of the groyne. Wrought-iron tie rods were fixed at intervals to the upper portion of the long piles to give additional strength to the groyne. The planking was 2½ in. thick, spiked to the windward side. The upper portion of the groyne was constructed level, and then fell 3 ft. in 120 ft. to the *ramp*, or quick fall of 6 ft. in 20 ft., followed by a fall of 16 ft. in 148 ft., making the total length of the groyne 328 ft.

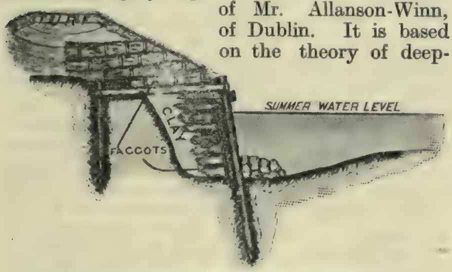


28. TIMBER AND RUBBLE GROYNE



29. PROTECTIVE WORKS FOR FORESHORE

The Cable Groyne. A new method of protecting foreshores from the sea has recently been employed at Bray. This system is known as "cable groyning," and is the invention of Mr. Allanson-Winn, of Dublin. It is based on the theory of deep-sea erosion—that is, of erosion of the ocean bed below low-water mark and the consequent driving forward of the low-water line. In order to prevent this erosion, and to encourage the deposit and retention of the material, Mr. Winn employed chains (the weight of which must vary according to the locality). To each of the chains were attached trees, crates, faggots, etc., one end being fixed to a pile placed near low-water mark, the other being anchored out at sea at any distance or depth of water, thus forming a flexible hedge-like groyne below low-water mark. After a few weeks observation, Mr. Winn found that some few feet of sand and shingle had been collected by the groynes, which were soon entirely buried.



30. TIMBER PROTECTION FOR BANKS

Waves. The height of waves is an important factor in dealing with sea walls, groynes, etc. The height likely to be attained at any locality by waves may be calculated, as they are found to be nearly "the ratio of the square root of their distances from the windward shore," or when h = height of wave, d = distance, and a = coefficient varying with the strength of the wind, then $h = a\sqrt{d}$. This formula (Stevenson's) may be taken to be $h = 1{\cdot}5\sqrt{d}$ in heavy gales, and in seas which do not differ greatly in depth.

In short reaches and in violent squalls, the following formula should be used:

$$H = 1{\cdot}5\sqrt{D} + (2{\cdot}5 - \sqrt[4]{D}).$$

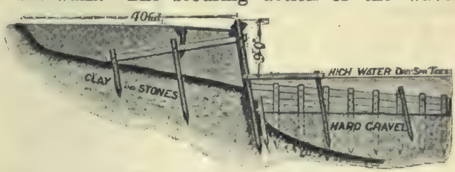
The force of waves may be calculated from the following formula: Let

x = the greatest force that can assail a pier, etc.,
h = height of waves due to the maximum effective exposure,
a = azimuthal angle between directions of pier and maximum exposure,

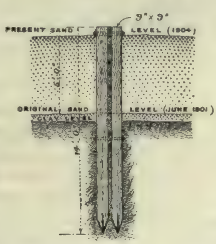
then, when the force is resolved normal to the line of the pier, x varies as $h \sin^2 a$, but if the force be again resolved in the direction of the waves themselves, x varies as $h \sin^3 a$.

The direction of waves is often altered when approaching the shore, this being due to the change of depth of water.

Sea walls are constructed in places where valuable property is to be protected, and, as before stated, their cost is justified. It is often found necessary to construct groynes to protect sea walls. The scouring action of the waves removes the beach, exposing the foundations, which are eventually undermined, and would, unless protected, result in the wall collapsing. The resistance of the wall to the waves causes the water to be thrown high up into the air, and in falling it scoops out and undermines the foundation. There are several methods of guarding against this. The face of the wall may be stepped, as in 22, or an apron of stones may be formed [23 and 24] to protect the toe of the wall. Where the wall has been constructed on hard rock, no such precautions may be necessary, as shown in 22.



31. TIMBER GROYNE

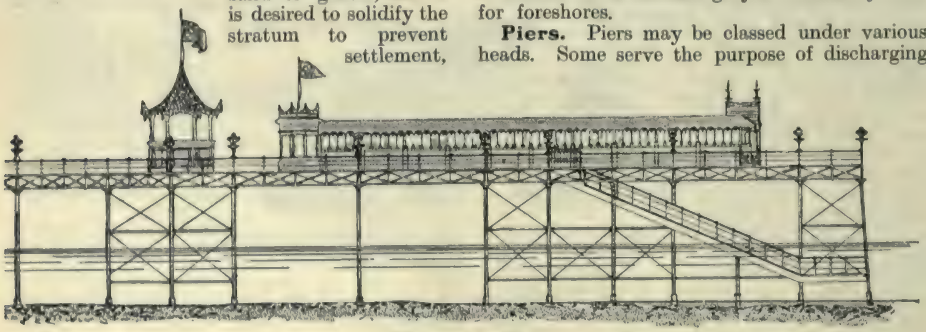


32. WOODEN GROYNE

Great care must be taken in constructing masonry or concrete sea walls or piers, on account of the action of the waves on cavities in the work. The air contained in a cavity is compressed by the impact of the waves, and in time disintegrates the work.

Stock-ramming. A method (first employed by the late Mr. Kinipple) for filling cavities and solidifying foundations is known as *stock-ramming*. It has been employed extensively and is worthy of description. The simplest and cheapest form of solidifying foundations,

stopping leaks, or filling cavities, is by stock-ramming. By this method liquid Portland cement grout is forced by a stock-rammer [25] through a tube or pipe into the crevices of the foundation; it solidifies, and forms a sound base. Should the foundation of the wall be sand or gravel, and it is desired to solidify the stratum to prevent settlement,



33. PIER HEAD

series of boreholes of from 2 in. to 6 in. in diameter are sunk at intervals along the line of wall. Pipes are inserted and grout is forced into the stratum on which the wall is constructed. Another method, where the stratum is soft, is to force into it balls composed of hydraulic lime mixed with clay, sand, and iron filings mixed with sal-ammoniac, Medina cement, or half-set Portland cement. These balls are driven down the tubes into the soft substratum by rams. On setting they form a hard foundation for the wall. Figure 26 shows this method in operation.

Protective Works. The following are brief descriptions of types of protective works: Figure 27 shows a form of rubble wall for protecting a bank which is not exposed to heavy wave action. Figure 30 is a method known as *facing*, for protecting a bank under similar conditions as 27, being commonly used for rivers.

34. DESIGN FOR PIER HEAD

Piles constructed from tree trunks are driven firmly into the ground, as shown by the illustration [30], and are braced together, the face of the bank being protected by close rough planking with a backing of faggots and clay. The foot of the bank is protected by heavy stones. This form is unsuitable if exposed to wave action.

Figure 31 shows a method of protecting foreshores where they are exposed to considerable wave action. This groyne, if properly placed, collects the drift, thus raising the level of the beach.

Figure 29 is an illustration of a protective work for a foreshore where there is heaving wave action. The timber framing is filled with block chalk, being enclosed by a facing of open planking. The toe is extended, as depicted by the illustration, to afford protection against undermining. Figure 28 shows another form of groyne. The block chalk or rubble is, in this case, enclosed by open planking. Figure 32 is a section of a wooden groyne commonly used for foreshores.

Piers. Piers may be classed under various heads. Some serve the purpose of discharging goods and passengers at seaports, or on rivers, like those at Dover, Folkestone, Liverpool, etc. Others serve the double purpose of training the course of a river, as on the Tyne, where two solid concrete piers are carried out to sea on the north and south sides of the mouth of the river. The object in this case was to confine the water in a defined channel at ebb tide, and so to remove the bar, which previously had to be constantly removed, or lowered, by dredging. The object has been accomplished, and a greatly improved navigable channel has resulted. The construction of piers in connection with harbours is dealt with in another section. We shall confine ourselves to brief reference to promenade piers which are a feature at many seaside resorts.

Figure 33 is an illustration of a promenade pier which the writer designed for a watering-place where it was desired to combine a means of landing passengers from pleasure boats, steamers, etc., with arrangements for bathing, together with the usual bandstand, refreshment rooms, etc. In this case the planks of the deck rested on girders supported on cast-iron piles.

The next illustration [34] shows in plan another pier that the writer designed for a simliar purpose. The planking of the deck is bolted to longitudinal iron girders resting on the iron cross girders placed on the top of the iron columns sunk into the foreshore and forming either a group of piles or merely two, if the width of the deck is small. The method of constructing the pier in all the details will be dealt with in another section, which treats of the design of piers.

Continued

THE SUCCESSFUL CATERER

The Principles Underlying Efficient Catering. Rules for the Good Housewife. Country Tea Cottages. Confectioners. Management of Restaurants

By A. B. BARNARD

WHETHER catering is to be done for a small household of four or five, or for a big institution such as an hotel, certain principles underlie its efficient performance We will state them summarily in the following paragraphs.

No thrifty housewife buys anywhere haphazard, nor does she, in a conservative spirit, continue to deal year in year out at the same shops. From time to time she compares the advertised prices of various firms with those she happens to be paying. The quality of the goods supplied must also be considered. For instance, it is false economy to buy inferior butter because it happens to be 2d. or 3d. per lb. lower in price than elsewhere, or dusty, stalky tea at 6d. per lb. less than that of a good blend. Such test purchases are possible in all large distributing centres, but outside these the caterer is more or less dependent on the local dealer, failing whom, it is best to order groceries direct from London stores or those of some large provincial centre. The street vendor of vegetables and fruit is not to be despised, for his price is usually less, and the articles often fresher, than those at shops. After a few experiments reliable dealers may usually be found, who are well pleased to get good, paying customers on whose orders they may depend. In the case of greengrocers and fishmongers, freshness and good quality of the provisions, and punctuality in their delivery are two most important points of recommendation. It is annoying to have a dinner spoilt by the non-arrival of a joint or poultry, or to receive it in an uneatable condition.

Knowledge of the chemistry of foods is of great value, since on it depends the making of dietaries and the planning of good menus—good in the sense that the dishes supply the right amount of flesh and fat-producing foods required to keep the body in a healthy and well-nourished condition. [See PHYSIOLOGY and HEALTH.]

Knowledge of How and When to Buy. Conservatism in diet is the great stumbling-block of English housekeepers, who fail to realise the great importance of ringing the changes on available food supplies. Our versatile neighbours across the Channel lift their hands in dismay at the automatically recurring porridge, bacon, bread and butter, eggs, and again porridge, bacon, bread and butter, eggs, year in, year out. Heat-producing porridge and fried bacon on a hot summer morning! Good digestion waits on appetite, yet how unappetising are many of our meals. In hot summer weather why not try one of the following by way of a change: cod-fish balls, soft roe (bloater's) on toast, steamed apples and oatmeal, tomatoes and eggs, tomatoes and macaroni, dates and whipped cream, sliced bananas and cream, or figs and hominy?

Some provisions are economical purchased in large quantities, providing, of course, that there is room in which to store them. Certainly those who manage hotels, boarding-houses, and institutions of various kinds should lay in stocks of potatoes, apples, onions, sugar, tea, bacon, flour, rice, tapioca, pickles, dried herbs, and condiments; these, together with jams, preserved fruits, and biscuits in tins, keep well in a dry and airy store-room or cupboard, and are less expensive purchased in bulk.

Economical buying does not necessarily mean purchasing at a low price, since a cheap article is often the dearest in the end, but getting the best return for expenditure. The ability so to do is perfected by experience, but rests mainly on knowledge, commonsense, and forethought.

The times when certain foods are in season need to be known and tabulated for reference, for in this way the thrifty caterer keeps in touch with times and seasons, and runs no risk of paying fancy prices for articles nearly or quite out of date. Oysters will not be ordered in July, cauliflowers in December, pork in August, nor rabbits in May. [See Table of Provisions, page 1531.]

Economy and Cleanliness. A thousand and one economies are practised by good providers, who bear in mind the maxim, "Waste not, want not." There are various ways of using up odds and ends, especially in the case of cold meat. For these the reader is referred to Cookery.

Our French neighbours show their greater economy in cooking in a variety of ways. They utilise the head and feet of a fowl, the eyes of a fish, the brains of a horse; the last, in fact, appears in the dietary of an invalid. Thus, parts of an animal which we despise and throw away aid in the production of tasty dishes. Then again, to what an extent are plants, some of them regarded as weeds by us, used across the water. An excellent salad is there made from dandelions, and wood sorrel can be employed in the same way. Nasturtium leaves may be utilised for sandwiches, mountain-ash berries and hips for jam, young nettle leaves as a substitute for spinach, and maize for porridge.

In planning menus, not only is a knowledge of the constituents of foods desirable, but also foresight in the ordering of provisions. To ensure this, daily visits of inspection should be paid to the store-room, so that any article running short may be renewed in time, and the cook will not suddenly discover that she wants potatoes, baking-powder, or pickles.

There is no more certain road to failure for the restaurant or tea-shop than want of cleanliness in either the preparation or serving of food. Customers will pass the door of a place which recalls unpleasant memories of smudgy plates and glasses, stray substances where they ought not to be, and tablecloths suggestive of microbes.

Detection of Adulterated Food. A caterer should always be on the look-out for adulteration in articles of food. Tea is much adulterated by intermixture with elm, beech, elder, oak, willow, and hawthorn leaves, unscrupulous dealers not hesitating to mix dried or exhausted leaves with good ones; coffee is adulterated with mahogany sawdust or coloured beans, cocoa with starch, bread with potatoes and alum, and butter with mutton fat. Chicory may be detected by scattering a sample on cold water—the coffee, which contains oil, floats; the chicory sinks, leaving a coloured streak. Mustard is adulterated with

wheat or rice flour; to detect this the alleged mustard should be boiled and a few drops of tincture of iodine added. This will colour the flour blue. A short time ago a girl who was admitted to a London hospital was found to earn a living by making wooden seeds for raspberry jam.

Good Accountancy. Daily provision for the needs of the family presents to the majority of people the most familiar aspect of catering. Partly in imitation of Continental ways, and partly to evade the domestic servant trouble, there is a growing tendency in cities to take all meals, except breakfast, at hotels and restaurants. In up-to-date West End flats a restaurant will be found on one of the floors, to which a lift conveys the residents with less exertion than is required to reach the dining-room of a country mansion. Such conditions are at present exceptional, however, and most housekeepers cater for their own families. Naturally, the cost per head per week depends on the style of living. For a family of over four people 15s. is a very usual allowance, and permits of good living; 10s. would be enough for a nice table; 8s. 6d. provides a sufficiency, and, with careful management, 6s. will obtain enough plain nourishing food; 17s. 6d. to £1 should provide very good living. We are, of course, supposing normal conditions—efficient and economical management, average appetites, and markets which are easily accessible.

The locality of the house considerably affects the weekly expenditure for food, a shop in a district catering only for wealthy customers charging proportionately high while another in a less fashionable neighbourhood has a lower scale of charges for similar goods.

Rules for the Household Caterer. The household caterer should bear in mind the following rules:

1. Do your own marketing, and see a thing before you buy it. Butchers have a little weakness for sending a larger joint than the one ordered.

2. Pay cash, run no bills, and so get the best quality at the lowest price in addition to independence of custom.

3. Study price-lists, and avoid cheapened foods.

4. Buy foods in season.

4. If possible, carry home your purchases, as Continental housewives do. They are seen early abroad carrying provision baskets, or followed by a maid doing so.

5. Give plain, straightforward orders if you wish for good service.

It is false economy to stint the members of the household of good, nourishing food, for the shillings so saved are apt to find their way into a doctor's pocket. The problem is to know what foods and what quantities are necessary to produce the maximum efficiency of all the vital functions. Then, too, one man's food is another man's poison. Eggs are positively injurious to some people; sugar is necessary to children, and fat to thin persons. The diet of children should alter with their growth. Some persons with quick digestions need a light meal every three hours, and may even require a relay of refreshments by the bedside. Hence there can be no hard-and-fast rules for dietaries, and home catering affords scope for intelligent study, observation, and experiment.

We now proceed to discuss catering for the public in various ways, beginning with the humble sphere of the street vendor.

Street Hawkers. A familiar feature of suburban life is the barrow on which fish, vegetables, fruit, ice-cream, mineral waters, potatoes, or chestnuts are hawked about. In the unfashionable districts of a city the street seller can, for a few shillings, lay in a stock of his wares, and if he be a capable buyer and secure a good pitch, may in his limited line prove a formidable rival to a neighbouring fruiterer, who has rent to pay, while the costermonger either owns his barrow or hires it for a small consideration. The man is usually aided by his wife or daughter, and gets regular customers on his rounds. He must be early at the market—Covent Garden or Billingsgate, and, as he is out in all weathers, has a rougher life than his brother in the sunny climes of the South, where street sellers are ubiquitous.

Villages have usually some kind of ginger-beer shop—where ginger-beer or lemonade is bought at 9d. a dozen and sold at 1s. 6d.—or a small inn as the only place offering refreshment to the wayfarer; and usually the food, surroundings, and charges are anything but satisfactory. Owing to the increase of cyclists and motorists, there is a good opportunity for women to start tea-rooms catering for such customers, preferably near villages or small towns.

Country Tea Cottages. An attractive cottage on a high-road, say, along the Thames Valley, would answer the purpose, provided it had a garden with flowers and a few shady trees in front, under which afternoon tea could be attractively set on small tables. A legible and artistically-painted sign board, indicating that refreshments or teas are there provided, should be placed in a prominent position. To make such a venture, a capital of a few pounds is wanted to buy tables, chairs, table-linen, crockery, and cutlery; but in order to insure success and pocket £30 to £50 profits, spotless napery, dainty tables, prompt service, good bread (preferably home-made), butter, cakes, jam, cream, and tea or coffee are required. Home-made lemonade is always appreciated. Mustard and cress and salad from the garden, eggs from a poultry run at the back, watercress from a neighbouring stream, and home-made preserves might go to increase the profits as extras. Necessarily, a room or shed should be available in bad weather. Cyclists and motorists prefer a dainty tea costing about 1s., nicely served in pleasant surroundings, to that obtainable in a stuffy inn, and would probably recommend it to friends. Undoubtedly a demand for such refreshment places exists, and to two or three practical girls desirous of adding to a limited income such a scheme presents possibilities.

Confectioners and Bakers. Apart from the regular business of the baker and confectioner, refreshments are provided in their shops. Teas for 6d. or 8d. (including tea, two slices of bread-and-butter, one cake or pastry) would cost about 3d., yielding half profits. Tea, bread-and-butter, cake, jam, with lettuce or watercress supplied ad libitum, for 1s. would prove very profitable. Ice-creams give a full half profit or more, such as sell at 6d. costing a little over 2d. Milk-and-soda, home-made lemonade and sweets are specialities which can be made to pay well. Some women who have had a small confectioner's business and have made a modest beginning by "obliging with a cup of tea," do quite a large business in lunches, teas, and breakfasts. Outside catering for supper parties, afternoon weddings, At-homes, musical parties, Cinderella dances, conversaziones, and children's parties, is a natural offshoot, and usually yields somewhat less than half profits.

Charges for Parties and Dances. We here give arrangements, menu, and charges for such entertainments, as furnished by a suburban confectioner :

Charges : 50 guests, 3s. 6d. per head; all over 50, each person, 3s. 3d. 100 guests, 3s. per head; all over 100, each person, 2s. 6d. 150 guests, 2s. 9d. per head; all over 150, each person, 2s. 3d.

Menu : Tea, coffee, white bread-and-butter.

Ices : Strawberry cream, vanilla cream, lemon, water (others if required).

Iced drinks : Lemonade, claret cup, mineral waters.

Cakes : Madeira, pound, cherry, etc.

Biscuits of various kinds, macaroons.

Fancy pastry of various kinds.

Assiettes of sandwiches : Ham, tongue, eggs, and cress, etc.

Lobster and oyster patties, etc.

Lemon jellies, strawberry cream, meringues, tipsy cake.

Dessert (in season).

For suppers : Consommé soup (on departure).

This includes use of all plate, glass, china, buffet tabling, silver urns and candelabra, and plants in silver pots. The services of waiters and waitresses are also included. Dishes left over are returned.

Ball suppers can be provided in an hotel at 5s. per head per 100 guests.

For a £1 menu would be provided sandwiches, boned turkey or bird, mince-pies, sweets (jellies, blancmange, creams), fruit, lemonade. Waitresses in this case are charged for at 10s. or more, according to contract.

In the case of wedding breakfasts, the bride's cake is, of course, not included. At a good hotel a wedding breakfast can be provided at 15s., 17s. 6d., £1 1s., or £1 5s., according to the menu. Such entertainments are, however, since the extension of the hour of the marriage service from 12 to 3 o'clock being superseded by the more desirable wedding tea, which not only permits a larger number of guests, but may be served in the garden.

The charge per head for school treats ranges from 4d. to 9d., the latter sum providing tea, bread-and-butter, cake, and jam. Lunch for teachers and visitors at school treats is supplied at 1s. 9d. to 2s. a head.

Occasionally a confectioner's shop is situated near some public ground or park, where cricket and football matches, flower shows, and fêtes are held. This is an opportunity for the confectioner to supply tea, bread-and-butter, cake, jam, with lettuce or watercress ad libitum for 1s. Large cricket and tennis clubs run their own refreshment-rooms in the club buildings, and make considerable profit thereby in the season.

Large hotels have ample accommodation for dinners, wedding receptions, and ball suppers. When rooms are not specially built for the last purpose, the coffee and billiard-rooms may be utilised, the coffee-room for dancing, and the billiard-room as a buffet.

London Tea-shops. To give an adequate account of London tea-rooms and restaurants is a gigantic task. The "London Directory" gives a list of 414 refreshment-rooms, 762 dining-rooms, and 1,712 coffee-rooms, making a total of 2,888 eating-houses. Allowing each 200 customers a day gives a total of 600,000 meals, probably only a small portion of those actually supplied. Time was when the City man regularly took up to town a tin of sandwiches for his lunch; now establishments of the Aerated Bread Co., Ltd., J. Lyons & Co., Ltd., Slaters, Ltd., the Cabins, Ltd., the British Restaurant, Ltd., and others are found east and west, north and south. At such places a cup of tea or coffee costs 2d. or 3d.; roll and butter or cut bread-and-butter, 2d; cake or pastries, 1d. or 2d. According to the "Stock Exchange Year Book" for 1906, the following dividends were issued in 1904-5: J. Lyons & Co., Ltd., 30 per cent.; Aerated Bread Co., Ltd., 6s. 6d.; Slaters, Ltd., 16 per cent.; Express Dairy Co., Ltd., 2½ per cent. for the half-year ending in August, 1905.

Artistically decorated tea-rooms of a higher grade are increasing in the West End, and are used as lounges. The large stores and drapery establishments have found it necessary to attach tea-rooms for their exhausted customers.

Restaurants. The successful restaurant of the present day must not only provide a lunch or dinner daintily served and well cooked, but it must be eaten in an artistically decorated room, with smoking, card, and chess-rooms attached. The restaurant of the future promises to be very luxurious, containing bath-room, reading-room, and hairdresser's—a place, in fact, where the whole day may be spent.

The custom of giving dinners and supper parties at restaurants and hotels instead of at home is on the increase, partly due to the saving of trouble and also to lack of space in flats and difficulty of getting reliable domestic help.

For the benefit of those who dine à la carte, it is usual for a restaurant to display at the entrance the menu for the day, with the price of each dish; thus the City youth can estimate to a penny the cost of his meal—say, 6d. for meat or fish, 2d. for vegetables, 3d. for pudding, and 1d. the waitress. The last item runs to 1d. in the shilling, or 2d. in the shilling in high-class places. In the same restaurant luncheon à table d'hôte at a charge of 1s. 6d. (four courses) is common, ranging elsewhere up to 3s. or 3s. 6d. There is good scope for a shilling table d'hôte lunch, and it has recently been started as an experiment by the Aerated Bread Company, a typical menu including green-pea soup or fried turbot; roast beef, stewed rabbit or cold meats; potatoes, sprouts; rice pudding and prunes, or cheese and celery. With such a liberal menu, the portions cannot, of course, be very ample.

Let us examine (1) a City restaurant, established nearly thirty years, and (2) one of the modern type.

The Old-established City Restaurant. The restaurant we have in mind lunches, on the average, 400 people daily. The rental, rates and taxes amount from £600 to £700 per annum. The staff totals 30 persons—18 in the kitchen, six waitresses, and six at the counter and cashier's desk. The wages in the kitchen are from 12s. to 20s. per week, with board and lodging if required. Waitresses get 5s. per week, with board and lodging, their total earnings, including tips, amounting to some 30s. a week. Their average hours are eleven a day. Once a week they get off at four, and once a month have Saturday free. There is an annual holiday of nine days in summer, four days at Easter, Christmas and Boxing Days, and all Bank holidays; no Sunday work. The waitresses are trained from the time they leave school, and remain for years, leaving usually to marry. The wife of the proprietor personally supervises the kitchens. The same tradesmen have been employed for some 27 years. Orders are sent them each night for the next day, and they quite understand that any inferior provisions would be returned; hence the food is of excellent quality. Arrangements are also made with market salesmen. The kitchens are under-

ground, but the difficulty of ventilation has been removed by the use of Blackman ventilating fans. By means of two Ewart geysers, boiling water is obtained a minute after the gas is turned on. The kitchens are whitewashed three times a year, and the whole place is scrubbed down daily. One lift conveys the plate ordered, bearing a slip of paper initialled by the waitress through whom it was ordered, the other carrying down the empty plate. Broken food is given away.

It will be evident that such a restaurant, conducted in a homely fashion, has its own clientèle, which needs careful working up. Let us now consider one managed on different lines.

The Modern Restaurant. This restaurant belongs to a limited company, is conducted by a lady manager, is open from 9.0 to 7.0, provides some 300 lunches, and serves some 400 customers daily. Provisions are weighed and measured as they come in, and include 100 lb. of meat (Scotch beef, New Zealand mutton, and English meat), 18 lb. of fish, 3 cwt. of potatoes, and other vegetables by the sack or dozen. There is no place for cold storage, but supplies are obtained through provision merchants and contractors. The chef is English, foreign chefs having usually proved uncertain in temper, violent in language, and wasteful. The kitchen staff also includes two boys, who clean knives, perform pages' duties, clean brasses, and do most of the outside work, a general help, one girl for plates, and another for light washing up; also vegetable and pastry-cooks. The floors are scrubbed before 10.30, the whole premises and staff being ready for business by 11.30.

The charges for table d'hôte lunch are 1s. 6d; à la carte—meat 6d. or 8d., vegetables 2d., sweets 3d., bread 1d., coffee 2d. Sixpenny teas provide one pot of tea, three slices of bread-and-butter, jam, marmalade, or watercress, and pastry or a piece of cake; but they have not "caught on," the same articles ordered separately, and costing 7d. in all, being preferred, so imperative is Dame Fashion. Exclusive of rent, gas, rates and taxes, the business returns half profits. It has been found by experience that a woman makes the most trustworthy and efficient manager—that is, of course, provided that she has special qualifications for the work, and does not follow the bad example of the male manager in leaving his post at will and failing to check weights and quantities.

Work and Earnings of Waitresses. The waitresses include eight in the two main rooms, six in the dining-room, and two in the smoking-room, besides a cashier. A dressing-room is reserved for their use; their hours are 9.0 to 7.0 daily, and 9.0 to 3.0 on Saturdays, with one week's holiday in summer. On arrival in the morning, they dust, spread fresh cloths, clean silver and cruets, and arrange the tables by 11.0. The charge of three tables with six customers at each is the portion of each girl. She takes her meals on the premises as opportunity offers. The wages are 6s. a week, and as 5s. a day represents the best harvest of tips, she depends mainly on these. Earnings of £1 to £1 10s. a week are exceptional. By the way, the announcement "No gratuities" is misleading and unfair to the girls. A system which provides an insufficient living wage, and leaves it to the waitress to get what she can out of a customer, is a degrading and demoralising one. Waitresses are even known amongst one another as "penny girls" and "twopenny girls." The non-tippers are called "slopers." Threepenny tips are things to be remembered, and experienced hands regard 2s. 6d. to 3s. 6d. in tips an average for a hard day's work. It may be remarked here that some firms deduct from wages so much for breakages, whether done or not, make the waitresses provide their own uniform and pay for the washing of collars and cuffs.

In our up-to-date restaurant the chef starts with a salary of 32s. a week, rising to 60s. a week, with a bonus of two guineas when the profits exceed a certain percentage.

Methods of Ordering Provisions. One restaurant company runs its own shops—butcher's, dairy, etc.; others send an agent to market. One has a distributing centre, where a staff of 2,000 is engaged in cooking and preparing provisions to be distributed at the various depôts, and where cakes, etc., are made during the night. It has its own buyers. Dairy produce is bought in the open market, and teas are obtained direct from India and China, and blended. Here the waitresses are paid 10s. a week and commission, and the annual holiday lasts from one to three weeks, according to the length of service.

The various coffee-houses and vegetarian restaurants claim a few words, since they are run on peculiar lines. The former are often dead failures, because they lack cleanliness and brightness, and thus instead of encouraging temperance drive would-be customers away. The latter are winning favour and increasing in number, for a well-managed and attractive place has a good prospect of success; one, with Oriental decorative work, which makes a feature of Indian, American, and Italian dishes, and provides a table d'hôte or à la carte lunch for 1s. 6d., and dinner for 2s. 6d., is very popular.

Coffee-stalls outside railway termini are open early in the morning for the late wayfarer or early worker. They supply a slice of bread-and-butter for ½d. and a cup of coffee for the same sum, and are largely patronised by workmen who come up to the City in the early trains.

Waiters and their Tips. The method of payment of waiters varies even more than that of waitresses. They may be paid a fixed wage and commission, a commission only, or may even pay for the privilege for working, recouping themselves entirely by tips. Such a livelihood is, of course, precarious, yet many find it profitable. In high-class establishments in London they may earn from £150 to £200 a year. At a well-known West End restaurant, where thirty waiters are employed, they are at work early in the morning preparing the hors-d'œuvre, go off duty till 5.30, return and work till 12.30. They are foreigners, who usually have the advantage over English waiters in being well trained and knowing several languages. At this same restaurant an excellent dinner of eight courses is provided for 2s. As the proprietor remarked, success depends entirely upon one's skill and knowledge of the business. One man, a few doors off, could not provide a similar dinner at 3s. 6d. In forty years he himself has reaped a fortune. As another instance of fortunes made in restaurants, one might quote the founder of "à la mode Beef Dining-rooms," established in Gracechurch Street in 1837; he left a fortune of £40,000.

As vegetarianism appears to be winning converts, we shall probably before long be well supplied with restaurants of this type.

Continued

ARTIFICIAL MANURES

Potash, Phosphates and Nitrates. Agricultural Consumption in United Kingdom. Sources, Manufacture and Analysis

Continued from page 5471

By CLAYTON BEADLE and HENRY P. STEVENS

Owing to the removal of certain constituents of the soil by growing plants, the land will soon cease to yield full crops unless artificial means are adopted to make good this loss. There are a large number of elements which are essential constituents of plant food, and Nature yields an abundant supply of most of these in the soil, air and rain. On the other hand, the elements potassium, phosphorus and nitrogen are present either in insufficient quantity or in a form not readily available to the plant if large yields are required. Different plants require the addition of different constituents, and for all information dealing with the practical application of manures we must refer the student to the course on Agriculture. We are concerned here only with the fact that compounds of potassium, phosphorus and nitrogen are required which must be available to the plant, and we shall show whence they may be derived and what manufacturing processes they undergo to prepare them in a suitable state for application as manure.

Potassium Salts. We have in our own country an ample supply of sodium compounds in the form of salt deposits, such as those in Cheshire and elsewhere, but we have no corresponding potassium salts close to hand, and we are, like most other countries, largely dependent on supplies from Germany, and apparently we shall always be so.

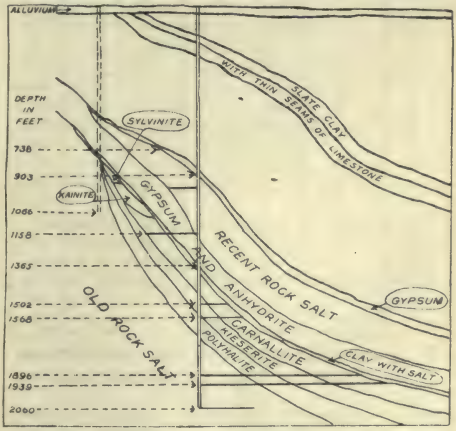
The rock salt deposits have been worked for very many years at Stassfurt, in Saxony, and about 40 years ago deep borings were made to see if a better supply could be discovered, with the result that enormous quantities were found a thousand feet or more below the surface. Above the deposit termed the "older rock salt," were large quantities of saline substances which were originally thrown aside as useless and termed "abraum salt," as they had to be cleared away to get at the rock salt (German, abräumen). It was not until some years later that people began to realise that these salts, containing large quantities of potassium, were of far greater value than the rock salt itself, and that they would eventually constitute the greater part of the world's supply of potassium compounds. Previous to this we were dependent for our supplies of potash on other sources, which did not, however, yield a fraction of what is now produced at Stassfurt.

The word *potash* is derived from "pot ashes"—that is to say, the ashes left in pots after the burning of wood. Wood, like all vegetable matter, contains certain potassium salts which are left as potassium carbonate in the ash.

Similarly, potassium salts are obtained from the residues of the beet sugar industry and kelp, certain varieties of sea-weed formerly much used in the manufacture of iodine. India also produces a certain quantity in the form of potassium nitrate; but all these sources together do not amount to more than 20,000 to 30,000 tons per annum, while the output of the Stassfurt beds amounts to 3,000,000 to 4,000,000 tons.

The Potash at Stassfurt. It must not be supposed that chemically pure potash is found in the earth and simply has to be dug out in this condition. Not only do various salts of potash occur, such as the chloride, sulphate, etc., but they are found in combination or admixture with sodium and calcium salts.

These *salt beds*, as they are called, were probably formed by the evaporation of the water of inland salt lakes, connected with the ocean by narrow channels. As the water evaporated, it was replaced



1. SECTION SHOWING A STASSFURT POTASH MINE

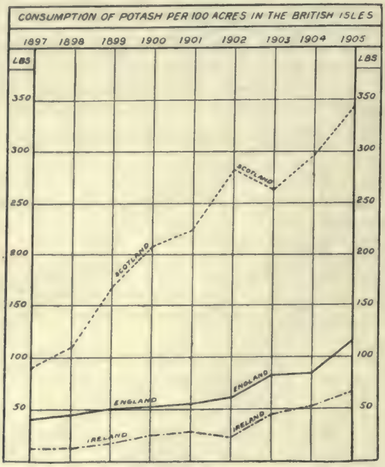
by fresh salt water from the sea, so that the lakes eventually contained so much salt that it began to separate out on the bottom. We are able to follow the order in which the different salts were deposited, by a study of deep borings that have been made; the diagram [1] will help to explain this.

The first to deposit, as being the least soluble, was anhydrous calcium sulphate, or "anhydrite"; then came the very extensive deposit of older rock salt. This bed is 3,000 ft. thick, and is supposed to have taken 13,000 years to form. Above the rock salt came in order a number of combinations, or, rather, mixtures of different salts in definite proportions: polyhalite, kieserite, carnallite, kainite and sylvinite. Of these, carnallite, a double chloride of potassium and magnesium, $KClMgCl_26H_2O$, is the most important. Above this is a narrow layer of salt clay. Now, clay is impervious to water, and the narrow layer formed a watertight roof to the potassium salts underneath. Had not clay been deposited, potassium salts would never have been found there, but would have been washed away long before by underground waters. On the top of the salt clay is a deposit of anhydrite and rock salt, but no more potassium salts are found above this.

It must not be thought that the layers of salt deposits are as sharply separated from one another

as represented in the diagram; their general position is, however, as indicated, and after mining, the salts are roughly sorted out as far as possible before bringing them to the surface. Except in some cases where the potassium salts are used straightaway as manures, they have to undergo considerable purification before they are put on the market. This is effected entirely by wet processes.

Concentration and Purification. The salts are separated by careful recrystallisation in large tanks, and extensive chemical works for this purpose have been built on the site of the mines. Carnallite is the chief source of potassium salts of commerce. It is treated in tanks with a



2. DIAGRAM ILLUSTRATING THE CONSUMPTION OF POTASH SALTS IN THE BRITISH ISLES

strong solution of magnesium chloride obtained in a previous operation. As potassium chloride is more soluble, the majority of this dissolves, and the residue left behind contains rock salt and kieserite (magnesium sulphate, $MgSO_4H_2O$). The soluble liquor containing the potassium salts is concentrated, and potassium chloride separates out, containing 25 to 30 per cent. of impurities. Many of these are removed by washing with cold water and a suitable process of recrystallisation, yielding eventually the pure chloride (or muriate) of potassium.

Kainite, another of the naturally occurring minerals, is a mixed sulphate of the following composition, $K_2SO_4MgSO_4MgCl_26H_2O$, and is worked up to remove the chloride. The mixed sulphates of potash and magnesia may be worked up for the manufacture of pure sulphate of potash or sold straight away for manurial purposes. The percentage of sulphate and chloride varies, but the potash is guaranteed 12·4 per cent. K_2O.

Potash in Agriculture. Although the manufacture of pure potash salts for various industrial purposes is of very great importance, the larger proportion of salts brought to the surface is used as manures after suitable treatment. In Germany, the seat of production, potash salts are generally used in the crude state, but it pays to purify or concentrate those salts destined for export. The consumption in Germany in 1905 amounted to some 514 lb. (reckoned as pure potash K_2O) per 100 acres of arable land; whereas in England it was 114 lb., in Scotland 341 lb. and in the United States 58 lb. The following is a list of the more important potassium compounds from Stassfurt used as fertilisers in this country:

- Kainite, containing 12½ per cent. pure potash.
- 90 per cent. muriate of potash, containing 50 per cent. pure potash.
- 80 per cent. sulphate of potash, containing 48 per cent. pure potash.
- Potash manure salts, a partially manufactured product, made in two grades, containing 20 and 30 per cent. pure potash respectively.

The varying proportions of *pure potash* contained in these "potash salts" is noteworthy, and should be taken into consideration by the agriculturist in determining the proportion of potash he intends putting on his land. In this country far more kainite is used than any other form of potash manure, something over 55,000 tons being imported into Great Britain in 1905, while muriate and sulphate of potash are in about equal favour, 3,000 to 3,500 tons of each being imported during the same period, and 6,000 tons potash manure salts. The consumption of potash in agriculture in this country is graphically demonstrated in the accompanying diagram [2].

The percentage of potassium salts should always be expressed as pure potash, as the farmer may be led astray by the contents of potash being made to look more attractive by being stated, say, as sulphate of potash, one part of potash being equivalent to 1·85 parts of the sulphate. The reader is referred to the excellent Board of Agriculture leaflet No. 72, which will be sent post free and free of charge on application to the Secretary, Board of Agriculture, 4, Whitehall Place, London, S.W. Letters of application so addressed need not be stamped.

Phosphatic Manures. The raw materials for the manufacture of these fertilisers consist of tri-calcium ortho-phosphate, $Ca_3(PO_4)_2$, in various forms, such as apatite, phosphorites, phosphatic rocks, and coprolites. The percentage of calcium phosphate contained in these substances varies considerably, Canadian phosphorite having 70 to 80 per cent., while phosphatic rock from districts on both sides of the Franco-Belgian frontier may contain as little as 20 per cent. The so-called "river" and "land" phosphates from South Carolina form one of the most important sources of supply, and carry 50 to 60 per cent. of calcium phosphate. Orthophosphoric acid being a tribasic acid, forms three calcium salts, the tri-, di-, and mono-calcium phosphates. The naturally occurring tri-calcium salt is an insoluble compound, and therefore not easily available to the plant. For manurial purposes it is converted into one or other of the two salts. Of these, mono-calcium phosphate or "superphosphate," is soluble in water and readily available. Di-calcium phosphate, although sparingly soluble in water, dissolves more readily in organic acids, such as citric, and in neutral salts. It is, therefore, more available than would at first appear.

Manufacturing Operations. For the manufacture of superphosphate, the mineral is ground up and treated for two minutes with sulphuric acid (chamber acid) in a lead-lined wooden tank provided with an agitator. The semi-fluid mass is then let down into a pit built of brickwork or concrete where the heat developed in the reaction raises the temperature of the mass to over 100° C., and a good deal of noxious gas is given off. The calcium sulphate formed in the reaction combines

with the water to form a solid mass of plaster-of-Paris, so that the whole sets, and is dug out with pickaxes. The lumps are then reduced to powder in suitable machinery.

The value of the superphosphate is based on the percentage of "soluble phosphates," which will average 25 to 27 per cent., but will naturally vary with the raw material, and may be as high as 45 per cent. Superphosphate containing as much as 87 per cent. soluble phosphate is obtained by Packhard's process, which consists in extracting the soluble phosphate from the calcium sulphate with water and concentrating the liquor with further quantities of mineral rich in calcium phosphate. In this form superphosphate has considerable advantage over the ordinary brands, costing much less for carriage.

If the mineral is of poor quality, or otherwise unsuitable for conversion into superphosphate, it may be extracted with weak hydrochloric acid and then precipitated with lime, chalk, or some waste product, as calcium sulphydrate from alkali waste. In this manner the so-called "precipitated phosphates" are obtained, consisting of the "citrate soluble" di-calcium phosphate.

Bones, bone ash and basic slags are all phosphatic manures. Bones will vary in composition according to previous treatment [see Glues and Adhesives, page 5357]; they may be treated for the manufacture of "superphosphate" on the lines already described, or merely ground up (bone meal). The basic slag formed in the Bessemer steel process by the combination of lime with the phosphorus of the iron, and containing 10 to 25 per cent. of phosphoric acid (P_2O_5) has been largely used of recent years as a phosphatic manure. The phosphoric acid is not taken up by the soil unless the slag is finely ground, which is effected in ball mills [see Cement-Making, page 1583]. The ground material should not leave more than 20 per cent. residue on a sieve with 100 meshes to the lineal inch. In buying phosphatic manures the farmer must take the same precautions as mentioned under Potash Salts; 142 lb. of phosphoric acid yield 310 lb. of phosphate of lime, so, to convert phosphoric acid to phosphate of lime, multiply by 2·2. It looks more attractive to see that a manure contains 26 per cent. of phosphates as against 12 per cent. of phosphoric acid, but, as a matter of fact, these proportions are equivalent, both manures containing the same quantity of the active ingredient. [See Board of Agriculture leaflet No. 72, already referred to.]

Estimation of Phosphates. Calcium and magnesium phosphates present in phosphatic manures may be rapidly estimated by a volumetric process [see also Analytic Chemistry, page 4403].

Uranium salts react with phosphates to give a yellow precipitate of uranium phosphate. The uranium solution—say, uranium acetate—is added from a burette until a drop of the liquid gives a brown colour with a freshly-prepared, dilute ferrocyanide solution on a porcelain tile. The brown precipitate consists of uranium ferrocyanide and shows that the standard uranium solution is in excess.

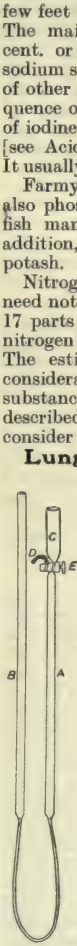
The standard uranium acetate is prepared by dissolving 35 grammes with 25 c.c glacial acetic acid, and making up to 1 litre. This is approximately equivalent to ·005 gramme P_2O_5 in 1 c.c. It is accurately standardised against a solution prepared by dissolving 5 grammes of calcium phosphate, $Ca_3(PO_4)_2$, suitably purified, in dilute HCl, and making up to 1 litre. The "phosphate value" of the uranium solution is then accurately determined by titrating 50 c.c. of the phosphate solution with the addition of 10 c.c. of a sodium acetate solution. The liquid is heated nearly to boiling when nearing the end point of the titration. The estimation of the substance under examination is carried out on a quantity of material containing about the same amount of phosphoric acid, and under similar conditions to the standardisation experiment. The sodium acetate solution mentioned above is made from 100 grammes sodium acetate, 50 c.c. glacial acetic acid, making up to 1 litre.

Nitrogenous Manures. In the republics of Chili and Peru are extensive desert tracts where nothing grows but a little coarse grass round the margins of its salt pools. This is the Chili saltpetre district, whence sodium nitrate is exported in large quantities to Europe, to be used either in chemical works or as a nitrogenous manure for the land. The deposits known as "caliche" lie only a few feet below the surface and vary in composition, The main ingredients are sodium nitrate 20 per cent. or more, sodium chloride 50 per cent., and sodium sulphate 5 per cent., with smaller quantities of other salts, particularly sodium iodide. In consequence of this it is one of the most valuable sources of iodine. Large quantities of sulphate of ammonia [see Acids and Alkalies] are also used as manure. It usually contains 24·5 per cent. ammonia.

Farmyard manure contains much nitrogen, and also phosphates and potash. Guano, seaweed, and fish manure are all nitrogenous, but contain, in addition, various proportions of phosphates and potash.

Nitrogen is often expressed as ammonia, but this need not deceive anyone if it be borne in mind that 17 parts of ammonia are equivalent to 14 parts of nitrogen and 66 parts of sulphate of ammonia. The estimation of nitrates in Chili saltpetre is of considerable importance in the valuation of this substance as a manure, and as it has not been described under Chemical Analysis, we shall consider it here.

Lunge's Nitrometer. It is convenient to introduce at this stage a form of apparatus devised by Professor Lunge and much used in analytical processes where a gas is evolved and has to be measured. It consists of two glass tubes [3], a graduated "measuring tube," A, and a plain "compensating tube," B. Both tubes are connected together at the bottom by a strong piece of rubber tubing securely "wired" on. The tube A at the top is fitted with a stopcock, E, doubly bored with slanting holes, so that the space in the tube may be connected either with the cup C or the outlet tube D, according to which way the cock is turned. Mercury is poured into the limb B till it about two-thirds fills both tubes, the cock E being set so that the interior of A is in communication with the air outside. The whole apparatus is supported on a suitable stand, which allows the tube B to be raised or lowered independently of A. On raising B the mercury will flow out of it into the tube A—in other words, the mercury will rise in A, driving out the air through the cock. On shutting the cock as soon as A is full of mercury, no air can be drawn in, even although the mercury in A tends to sink by the action of gravity on lowering B again to its former



3. LUNGE'S NITROMETER

position. On connecting D with the vessel containing the gas to be examined and carefully opening the cock in the reverse direction to that shown in **3**, the mercury in A will sink, drawing the gas in with it. On shutting the cock and adjusting the tube B until the level of the mercury in both limbs is the same, we can now read off the volume of the gas we are about to examine at the temperature and pressure of the atmosphere. [For the influence of temperature and pressure on the volume of a gas, see course on PHYSICS.]

Operating the Instrument. We now, perhaps, require to bring the gas into contact with a liquid which will absorb one of its constituents without affecting the others. Suppose our measured volume of gas to be a mixture of air and carbon dioxide, and that we wish to determine in what proportions they are present. Pour into the cup C a small quantity of strong caustic soda solution, then lower the tube B, and by carefully turning the cock to the position shown in **3** allow some of the caustic liquor to be drawn into the tube A, being careful to shut the cock before any air is sucked in. Gently agitate the liquid and gas in A, by raising and lowering B, thereby compressing and expanding the gas in A and covering the interior walls with a thin layer of caustic liquor, and so exposing fresh surfaces to the action of the gas. The measuring tube may also be unclamped if necessary, and the mercury shaken up with the caustic liquor and gas, but this operation requires care. When the action is believed to be complete, adjust the levels in the two tubes again, and read off the volume of the gas, which will now be smaller than it previously was by the volume of dioxide absorbed. Gentle agitation of liquid and gas should be repeated, and on again measuring the volume the same figures should be obtained as before, showing that absorption of the carbon dioxide gas was complete.

Nitrates. Salts of nitric acid are decomposed with strong sulphuric acid, when a mixture of the two are shaken with mercury, the whole of the nitrogen being converted into nitric oxide, NO. All that is necessary is to carry out this operation in the nitrometer just described, and to measure the volume of the gas in order to determine the amount of nitric acid (N_2O_5) in the substance analysed.

Proceed as follows: Weigh out such a quantity of the substance that the gas evolved will be easily contained in the graduated portion of the tube. To obtain an idea what quantity this will be, it may be stated that every cubic centimetre of NO evolved corresponds to 2·4 milligrammes of N_2O_5, so that ·38 gramme of sodium nitrate or ·45 gramme of potassium nitrate will yield 100 c.c. of gas. Run the mercury up the tube A until it passes through the cock E and just begins to enter the cup C. Close the cock, and place the weighed substance in the cup, with a small quantity of water to dissolve it. By lowering tube B, and gently opening the cock, draw the liquid on to the top of the mercury in A, but be careful to see that no air enters. Add a little more water to wash out the cup, and draw this into the measuring tube. 1 or 2 c.c. of water should suffice to get the whole of the substance into the tube. Then pour 15 or 20 c.c. of *pure* strong sulphuric acid into the cup, and draw this into the measuring tube, close the cock, and, unclamping the tube A, shake vigorously the mixture of liquids at the top so that the surface of the mercury is broken up into globules, which mix in with the acid. Set aside one hour to stand, then adjust height of mercury in both tubes, and read off the volume of gas, from which may be calculated the percentage of nitric acid on the basis of the figures already given. Allowance must be made for the fact that sulphuric acid is not so dense as mercury, and requires a column six and a half times as high as the latter if both are to balance.

Other Uses of the Nitrometer. This instrument can be used for estimating nitrites as well as nitrates, each cubic centimetre of NO being equivalent to 1·7 milligrammes of N_2O_5. It is also used a good deal for measuring the total nitrogen in "nitrous vitriol" [see Sulphuric Acid, page 4627]; also for the estimation of urea and ammonium salts. This requires a little further explanation. Instead of using sulphuric acid to effect the decomposition, its place is taken by a strong solution of sodium hypobromite, which liberates all the nitrogen, whether in urea or ammonium salts, in the form of the gaseous element itself:

$$CO(NH_2)_2 + 3NaBrO = CO_2 + N_2 + 2H_2O + 3NaBr.$$

Every cubic centimetre of nitrogen is equivalent to ·002952 gramme of urea. In addition to these the nitrometer can be used for the estimation of nitrates and nitrites in water and in a number of other analyses which would lead too far to go into here.

Nitrogen from the Air. The atmosphere surrounding us contains roughly four-fifths of its weight of nitrogen. We have, therefore, an inexhaustible supply of nitrogen, if only an economical method could be found for converting it into nitrates or other nitrogenous compounds suitable for manure.

The manufacture of compounds of nitrogen from the air by electrical processes has recently made great advances. Two processes are working on a fairly large scale; one of them converts the nitrogen into basic calcium nitrate, and in the other the nitrogen is obtained in the form of cyanamide. Both these substances are said to be suitable for direct application to the land.

The cyanamide process is due to Drs. Frank and Caro. It consists in passing nitrogen over calcium carbide heated to a high temperature. The substance obtained has the formula $CaCN_2$. Calcium carbide is at present manufactured in considerable quantities for the production of acetylene gas for lighting purposes. The nitrogen is obtained from the air by liquefying it and distilling the liquid. The second method is merely a manufacturing adaptation of the observations originally made by Cavendish (1784), who found that nitrogen and oxygen combine slowly to form oxides of nitrogen under the action of electric discharges. The conditions applied in practice depend upon the fact that "the yield is notably increased when the electrodes are placed in a narrow part of the chamber in which the reaction takes place, in order to submit the whole of the gas to the action of the electric energy, and to draw off as rapidly as possible the gases which have been subjected to this action." (Guye.)

Experiments are in prograss or small plants erected for working this process in Norway (Eyde & Birkeland), at Freiberg in Switzerland (Kowalski's method), and at Niagara Falls (Bradley-Lovejoy method). The gases obtained in the arc furnace chamber contain 1 to 2 per cent. by volume of nitric oxide, the remaining 98 per cent. or so consisting of inert gases. The problem of separating this large dead weight of inert gas economically is no easy one. By cooling the nitric oxide gas, it is converted into N_2O_3 and N_2O_4, which, by reaction with water and an alkaline solution such as lime water, yield nitrate of lime.

Continued

MACHINES & APPLIANCES

Unity of Practice. Typical Works. Organisation and Management. Training and Rewards. Technical Literature

Continued from page 5456

By JOSEPH G. HORNER

MANY of those who have followed the course on MECHANICAL ENGINEERING, and who, perhaps, have approached the subject for the first time, may have received the impression that, where so large a number of departments and highly technical subjects are involved, there must be inevitable isolation from one another. It seems a far cry from moulding to machine tools, from pattern-making to metal-turning, from milling to forging, from the work of the draughtsman to that of the boilermaker and plater. That is true in one sense. But we want now to show in a final article the *unity* of engineering practice, the underlying and essential relations which exist between trades and subjects so diverse. We shall show how the heterogeneous and extensive elements make up an organic, unified system, with all of which the true engineer must be familiar. We ask our readers, therefore, to accompany us through a few typical engineers' works, and to see how the great organisation is laid out and carried on. Then we shall see in what manner the requisite training is obtained, and how the ambitious youth is started on his enthusiastic career. For there is little chance of high success in engineering for those who have no love for the pursuit.

Machines and appliances are found in every department of engineering without exception, and are much more numerous in some than in others, but are nevertheless ubiquitous. They are the key to economic production, for success or failure in general depends more largely at the present time on the utilisation of the most suitable machines out of several possible than on any other single factor. And the secret of successful organisation is to so arrange these machines and appliances, and the several shops and departments in which they are located, in the manner which is best calculated to ensure their most economical operation from the point of view of *output.* And these questions of arrangement, location, organisation, it must be remembered, lies wholly outside that of the selection of the machines and methods most suitable to produce given results on individual pieces of work.

The Units. A modern engineer's factory, employing a small army of men, ranging from, say, 500 upwards to 2,000 or 3,000, spread over several acres of ground, containing a number of different shops [see page 2108], with appliances, tools and machines that number some thousands, requires good generalship. Every shop and every sub-department of the works is a unit distinct and separate in itself, a little world of its own, a complete microcosm. But it is, nevertheless, linked with every other shop and department in the vast works, and this is the point of view from which it has to be regarded in the offices. The work in every department must be kept moving relatively to that in every other, though the men in the various departments never intermix with or seldom speak to those in other departments or have any knowledge of what is being done elsewhere than in their own. But the management knows, and has to regulate the progress and sequence of operations so that all the individual sections of machines and structures will come into the erecting, or assembling, or store, or shipping department at the right time. This explains the apparent marvel of the erection of a bridge, or the building of a locomotive or a crane, or the equipment of a central station or a new factory in what seems an incredibly short space of time. It explains why a firm can turn out a complete engine every day, or a hundred sewing machines or typewriters in a week, and so on. The secret is arrangement, organisation, management, with all that is covered by those comprehensive terms. Let us consider these in turn.

Arrangements. By the word *arrangement* is understood the laying out of the various isolated shops and the best method of linking them together. This matter, highly desirable though it is, has not received general attention until within the last ten years or so. Everyone who is at all familiar with factories can call to mind scores of old works laid out without any regard to economical inter-communication between the units—the shops. Upstairs and downstairs, and a shop here and another yonder, with nothing but rough, dusty, or muddy yard between, encumbered with the wasters and rubbish heaps of a generation—that is the old style, in which a vast amount of time, which is money, is wasted within and without the shops in the mere hauling of heavy materials and work about by human muscle; often, too, backwards and forwards over the same ground, or up and down old stairs. Central control is largely lacking, and men do to a large extent what seems right in their own eyes.

But the modern style is this—shops arranged in parallel or at right angles, and located so that the cost of haulage is reduced to a minimum. The shops are arranged as much as possible in the same sequence as that of the course of the work. Raw materials come in at one locality, and the work in its progress moves onwards towards the final departments in which it is delivered completed. A system of narrow-gauge tracks—*light railways*—traverses the shops, and also connects all the shops, one with another adjacent. Turntables, and curves are fitted where necessary, and weighbridges lie in the course of the tracks at the place of entry and of delivery. Besides this, there is a system of hoisting apparatus in all the shops where heavy work is hauled—as in the foundry, the boiler shop, the turnery, and the machine and erecting shops. It comprises overhead travelling cranes spanning the entire width of a shop, and ranging anywhere between 5 tons and 100 tons capacity, varying with the mass of the work to be handled. It comprises swinging jib cranes ranged along the walls, to command certain areas, to cover certain machine tools, or foundry areas, or a smiths' forge, etc. It also includes overhead tracks for suspended hoists, which are run along over the

floors, or machines, to deal with a class of work too heavy to be lifted by hand, yet not heavy enough to require the services of the big cranes and travellers. To operate these cranes and various machines there are power installations. In a big modern factory there are generally four distinct power sets—steam, electricity, water, and compressed air.

Steam Power. The steam power of a works is not used for driving machine tools directly to the extent that it was a few years since. Its principal functions now are the driving of shop shafting and the supply of power to the dynamos for driving and lighting. Many independent machines that were formerly steam-driven, such as punches and shears, now have motors fitted. Many cranes formerly actuated by steam have been thrown out to make way for electric cranes. There is still, however, in many works a large number of machines and cranes that are steam-driven, besides the main shafting. The boilers generally used are of the Lancashire or Galloway type, though in many recent plants water-tube boilers of Babcock and Wilcox, or similar type, have been installed in preference [see Prime Movers].

Electricity. Electricity is without doubt the power agency which is destined to overshadow all others in factories, as elsewhere. Already many factories use electricity to drive shafting, or even abandon shafting for an individual motor drive to each machine. Cranes are driven thus, and even the lifting hook is being ousted in favour of the lifting magnet. Steam boilers and engines are required still, but the boilers that supply the power house are generally of water-tube type, and the engines are of high speed or high rotative speed type, coupled directly to dynamos.

The great advantage which the electric drive has over a system of steam pipes is the absolute flexibility of the electric conductor by comparison with the rigid steam pipes, with the condensation of steam therein—always an ever-present trouble. Many cranes and machines have their own independent boiler, but these are suitable only for outdoor work, as in yards, being intolerable in closed shops. An incidental point in favour of electricity is that a plant is required to supply light in any modern works, and the same, or a duplicate plant, can be used for power.

Water Power. There are certain operations in which the power of water, used at a pressure which ranges between 750 lb. and 1,500 lb. per square inch, holds a place that seems to be secure against the rivalry of the other power agencies. Whenever massive forgings have to be squeezed and shaped, or large steel plates flanged or bent, or heavy moulding machines pressed, or other operations of this general character performed there is no agent so reliable as pressure water. All works, therefore, which do massive forging and boiler work, heavy moulding by machine, forcing on of wheels over their axles, or machine riveting, must have a hydraulic pressure plant. This comprises engines and force pumps, accumulators and a system of very strong pipes with special joints to convey the water to the various machines. Formerly the same power was often used for the heavier fixed cranes about a works, and is so still in numbers of cases. But in laying down new installations, preference is now given to electricity for crane service, retaining, however, the hydraulic system for the duties just now specified.

Compressed Air. Compressed air, the youngest of the power agents, is also one that is very promising. Atmospheric air is compressed by a steam engine in a cylinder, usually to 80 lb. per square inch for factory service, and delivered at that pressure into a receiver resembling a vertical boiler in external appearance, and thence delivered to hoisting machines, to machines for riveting, chipping, caulking, hammering, machine moulding, and much beside. In the early days of compressed air, difficulty was experienced consequent on the elasticity of the medium, which produced jerky movements, difficulties due to heating and condensation, to wear of the valves, and to other mechanical details. These have been overcome, and air-operated tools and appliances are reliable. There is the objection to piping as in steam and water supply, but in some machines there is little rivalry even with electricity in the field. In chipping, caulking, hammering, sand blasting, compressed air has the field all to itself. The tiny engines and their mechanisms are marvels of design [see page 5455]. Only in light hoisting does electricity come into close rivalry with air, and that only since air has spread itself over this promising field. In all overhead track systems, the rivalry now lies practically only between two kinds of hoisting machine—the air-operated, and the electrically-driven travelling hoists.

Grouping of Machines. The design of the shops, and the grouping of machines within the shops, should obviously be made to conduce to economies in output. The old style was, generally, storied buildings, because the old shops mostly grew up in the heart of cities. As businesses were of slow growth, and space was limited, makeshifts were unavoidable, and this explains why the older shops, even those of the leading firms, are generally anything but modern in their arrangements. Heavy and light machines are grouped together instead of being separated, and upper floors are loaded with heavy machines that ought to be on the ground floor. In consequence of these difficulties many of the older firms have migrated to suburbs, built themselves new shops, and spread themselves out with room for future growth.

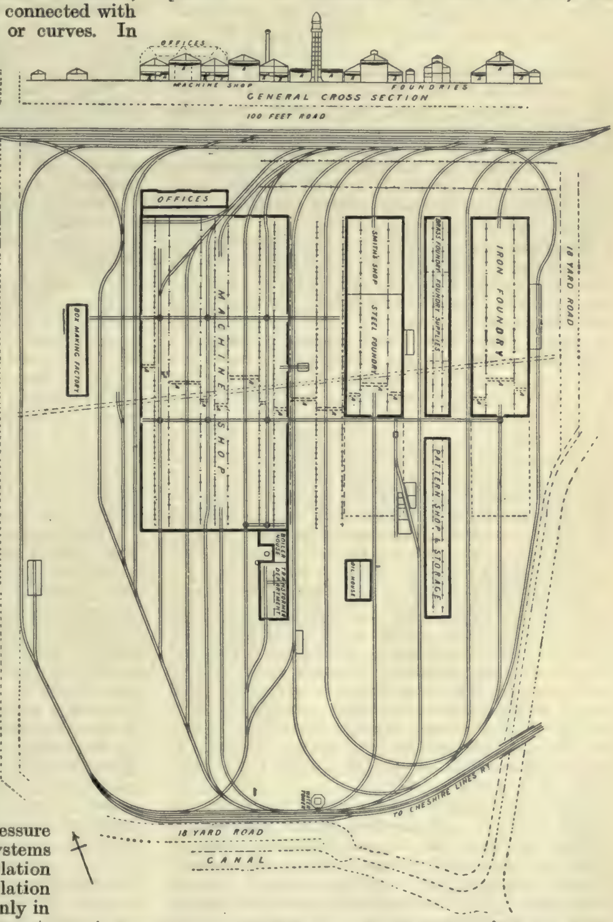
Buildings. Factory buildings may be grouped under two classes — the single-floor building, and the storied building. The former is suited for heavy machinery and massive operations; the latter for the lighter industries. The former is necessary in foundry work, forging, boiler-making, plating, bridge and girder work, in the construction of all massive machine tools, engines, cranes, and the heavier dynamos and motors. The latter is suitable for light brass work, as the manufacture of cocks, valves, gauges, pitch chains, and wheels, small mechanisms, sewing machines, typewriters, electrical apparatus, and so on.

But in nearly all factories there are heavy and light departments. There are light machine tools, bench work, assembling, fitting. Hence, we find that most factories have work on the ground floor, and work on upper floors, heavy and light respectively. Hence, a common type of building is that with a wide central bay, clear up to the roof, flanked with side bays, each with an upper floor. Or alternatively, side galleries are erected in the main building, still leaving the central area open to the roof. For most engine work these are the most approved arrangements. If the shops are so large that one bay is not sufficient, then the bays are simply repeated : two, three, or more, all

alike, and running parallel with each other. It is not necessary to separate these with walls if they belong to a single shop, as a moulding floor or a machine shop, but the pillars which support the roof principals are the only essentials present. Thus, the view within these large shops is simply that of a very large rectangular area, with a few rows of columns surmounted with girders erected to carry the roof principals. Each bay has its own separate sets of overhead travellers, cranes, and floor tracks, the latter connected with the shops adjacent by turntables or curves. In these shops the heavy machines are grouped by themselves, and the light ones in a separate area. Heavy lathes will occupy one department, where they can be served with heavy cranes, and light ones elsewhere; and so of other machines, as grinding, and gear cutting, and automatics, which are relegated to distinct areas. In foundries the machine moulding department will be kept wholly apart from the hand moulding. Floor work will be separate from bench moulding, loam from greensand, core making from moulding, etc.

Light. An essential in a shop is ample light, in which the old shops were sadly deficient. A shop open to the roof can be lit from the roof without any windows at the sides, though it is usual to include the latter. A continuous skylight is generally run along each side of the ridge. The *saw-tooth roof* is becoming more common, the idea being borrowed from the weaving sheds. Here direct sunlight is avoided, yet there is ample illumination.

Ventilation. The principles of ventilation and heating have been more honoured in the breach than in the observance. In modern works both are regarded. In the floor shops, open to the roof, a set of louvres along the ridge generally suffices for ventilation. Heating is more difficult. Heating by hot water on the low-pressure system is becoming usual. Some systems now combine heating with ventilation in winter, and cooling with ventilation in summer, but these are adopted only in a few engineering establishments as yet. The altruistic aspect of the factory is regarded more commonly than of old. Adequate and suitable lavatory accommodation is provided in many works, reading-rooms, libraries, and in a few instances technical schools, so that the younger race enjoy much greater privileges than their predecessors did.



1. TYPICAL ARRANGEMENT OF ENGINEERS' WORKS
(British Westinghouse Electric and Manufacturing Co., Ltd.)

Plans of Typical Works. Figure 1 illustrates one of the best laid out works in England, built at Trafford Park, Manchester, by the British Westinghouse El·ctric and Manufacturing Co., Ltd. The parallel lay of the shops, and the perfect intercommunication between them all, with the Cheshire railway lines, with the road, and with the Bridgwater Canal are the noticeable points in the plan arrangements. There is room for extension endwise of the steel and iron foundries, and in a lesser proportion of the other shops. The relative areas of the shops may be noted, as they are fairly typical. The machine shop is by far the largest, as it usually is in most engineers' works. It measures over 900 ft. in length, by 427 ft. in width, and covers between nine and ten acres. This vast width is divided into five bays, not, however, separated by walls, but by columns which permit of an unobstructed view. In fact, the buildings are steel skeleton-like structures on which all the loads of roof and cranes are carried, and the brickwork is merely a filling in to form walls.

Every shop where heavy work is done is served by tracks, which total to about ten miles in length. But then the area covered by the buildings amounts to 30 acres. The tracks are not, as is usually the case in works, of 18 in. or 24 in. gauge, but standard 4 ft. 8½ in. so that goods trains run into the shops when required to load or unload materials and manufactured goods. Where the tracks cross at right angles, turntables are used; elsewhere curves of 200 ft. radius predominate.

The ground floor and the two-storey and galleried types are represented here [see the general cross section]. In the machine shop two of the bays are open to the roof, and three are two stories high. The lighter electrical work is done here, largely by girls. The foundries are open to the roof. The iron foundry is 600 ft. long by 180 ft. in width. The brass foundry is 170 ft. long by 75 ft. wide. A number of powerful overhead travelling cranes serve the shops. These are indicated by the letters AA in the plan and general cross section. Most of them are of 50 tons power.

Another excellent lay-out is shown in 2, that of the works of the British Thomson-Houston Co., Ltd., Rugby. Here, two systems of tracks are employed. There is the standard 4 ft. 8½ in. in connection with the main line railway, and the "Hunt" system of narrow-gauge tracks serving the shops. The system is a most complete one, with turntables, crossovers, curves, switches. The drawing is self explanatory.

Sections. Figure 3 gives a section through four bays of the machine shop of Kendall & Gent, Ltd. The two middle bays are open to the roof, the two flanking ones are two-storied buildings, and both the ground floor and the upper one carry light machines. The floor which seems to cover the middle bays is not so, but an end gallery only.

The most approved method of supporting the roofs and the travelling cranes away from outer walls is here seen. Steel columns, lattice-braced, afford support to the roofs and the traveller runways, generally also to bearings for shafting. The columns leave free communication between bays. If a separation is required the spaces between the columns can be bricked in. But the brick filling carries no weight. This method is often adopted for outside walls. Steel columns carry the roof, and the spaces between them are bricked up.

Organisation of a Works. This phrase signifies the system by which the work of the various shops and departments is executed. It includes the commercial and the mechanical side, two very distinct groups which are seldom controlled by the same chief, or the same staff. Each requires knowledge and experience of a totally different kind from that of the other. Financing and manufacturing are as opposite as the Poles, but both are essential to the successful conduct of a business.

In the organisation of a factory, complete account has to be taken and recorded in the offices of all orders, the labour costs, the materials used, the prime costs due to all charges and expenses, the interest on and depreciation of capital, and the value of the assets. This entails an immense commercial system altogether apart from the tasks of actual labour. Of late years much more attention has been paid to the details of cost-keeping than formerly, and this has been favoured by the growth of the simple card system in place of cumbrous account-books. The work of the shops has to be preceded by estimates and tenders, by designs and drawings, after which the work is carried out under the supervision of managers and foremen.

The Management of a Works. After a factory has been laid out and organised, the duties of the managers are supposed to proceed within specified limits. Latitude and initiative are allowed and often encouraged, but not such as would interfere with the general organisation laid down. Thus, a manager or foreman is perfectly free to use his judgment in regard to varying the methods which have been hitherto adopted in the shop of which he has charge, but in doing so he must not interfere with those of another department that lies outside the sphere of his responsibility, and he must not do anything that would check the progress of the work. Any radical changes can emanate only from, or be sanctioned by, the general manager, or the managing director, who has supervision of the entire factory. Experience shows that undue interference with the heads of departments is injudicious. The best results follow when a free hand is given, subject to the above-named necessary limitations; to give a man responsibility, and to judge and pay him by results is the sure way of getting the best out of him.

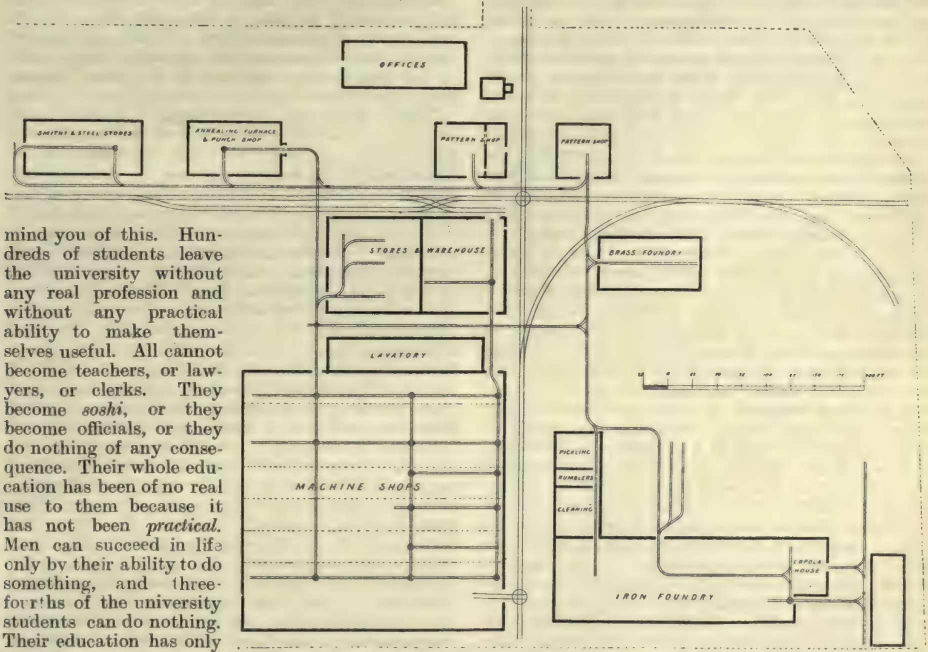
The Training of Engineers. The training of engineers and craftsmen is a question around which much controversy has been aroused in connection with the growth of the technical schools, and the increase in the unemployed in our streets.

The man who seeks success, either in the conduct of mechanical engineering works or in the practice of one of the separate crafts of the factory, can achieve it only by a combination of manual work and study. No man, however skilful he may be, or however excellent his opportunities of acquiring knowledge and experience may have been, can neglect without serious loss the recorded experience of others. To test it, write articles or letters to a technical journal stating how you have done certain pieces of work, and other readers will show you different, and perhaps better, ways of doing the same job. It is the same in visiting other shops, or in conversation with other men. The more you do in this way the less conceit will you have of your own acquirements. The greatest engineers are generally omniverous readers, and are discreetly modest.

Technical Education. The technical education of the schools cannot be kept out of the subject we are considering. Though the old engineers did without it, they would nevertheless have been spared many initial difficulties could they have stated them to a qualified teacher. The present danger is lest the place of technical training should be overrated. It must not be regarded as a kid-gloved, genteel device for creeping into engineering by avoidance of hard work. In that way lies certain failure. Successful engineering is not to be achieved by the cramming of facts from books and teachers. Facts, like tools, are of no value unless skill in their employment is acquired, and that is what the youth gathers in the shops. Hence the proper place of technical education is as an *aid* to the shops, not preceding or following, but *sandwiched in* with shop practice. But here the difficulty arises, because there is only one way to accomplish this—namely, to work in the shops in the day, and study at night; or to spend six summer months in the shops, and a winter term in the schools alternately. Some exclaim that this is burning the candle at both ends. Yes; and any young man who, destitute of capital and influence, means to rise above the common ruck, must do so. The youth who gives his nights to dissipation, and turns up sleepy and silly in the morning, burns his candle thus; then why should the youth with noble ambitions grumble? The life stories of the great engineers, in common with others, teem with records of men of whom it is literally true: "But they, while their companions slept, were toiling upward in the night." A passage in the "Life and Letters of Lafcadio Hearn" applies exactly to the present subject. He says (vol. 2, page 164):

"Science is difficult, really difficult; but everything worth having in this world is difficult to get

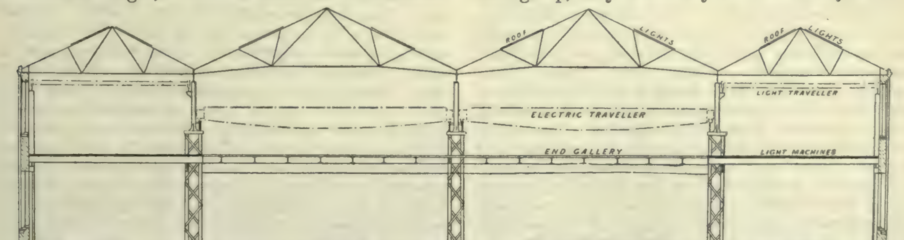
exactly in proportion to its value. The only question, I think, should be, 'What study will be most useful to me all through life?' but not whether it is difficult. What is important to know is always difficult to learn. And I would remind you of this. Hundreds of students leave the university without any real profession and without any practical ability to make themselves useful. All cannot become teachers, or lawyers, or clerks. They become *soshi*, or they become officials, or they do nothing of any consequence. Their whole education has been of no real use to them because it has not been *practical.* Men can succeed in life only by their ability to do something, and three-fourths of the university students can do nothing. Their education has only been *ornamental.*"



2. WORKS OF THE BRITISH THOMSON-HOUSTON CO., LTD., RUGBY

This expresses the attitude of employers and managers. The first question a youth or man seeking a situation is asked is, "What can you do?" or, "What work have you been doing?" or, "Where did you work last?" and not, "What have you learned?" or "What subjects have you studied?" The unemployed are too often unemployable. They have passed through the Board schools, but have not learned how to do the work that the world wants. The hewer of wood and the drawer of water whose sole capital is brute force has been displaced by the tireless machine. But the supply of skilled men is not equal to the demand.

Rewards. The question has often been asked, "What return can a craftsman expect for a course of technical study?" It is truly pointed out that the majority of men must remain manual workers at moderate wages, so that to these the inducement to study does not seem very attractive. Perhaps not, from the purely utilitarian point of view. Yet of old it was said, "Is not the life more than meat?" Though men may be poor, they can be of Nature's nobility. "Men, my brothers, men the workers, ever *learning something new.*" And the working youth may learn to feel as keen an interest in literature in general and in the literature of his calling in particular as in kicking or batting a ball. Besides, who is to say beforehand of a young man that "once a machinist, always a machinist"? Opportunities for advance are always offering in this world of rapid changes, but only those who are ready to fulfil the conditions demanded can avail themselves of the vacancies that offer. "The readiness is all." Moreover, the zest of life is not always felt so much in the success as in the struggles. There is joy in the battle, even though the final note of victory may not be heard. Therefore we say there is every reason why the youths in our shops should avail themselves gladly of all opportunities of increasing their knowledge by study, in season and out of season. Certainly, even if competence eludes their grasp, they will rarely be "out of a job."



3. SECTION THROUGH MACHINE SHOP (Kendall and Gent, Ltd., Manchester)

Apprenticeship. In all departments of engineering the knowledge of the craftsman can be acquired only by apprenticeship, or its equivalent. By this is meant going through the same duties as those of the apprentice for a term of years, but without the indenture. That is how most of the lads are now trained. The difference is only in name, and in the fact that the period of tuition is terminable on either side at a moment's notice. This, however, happens only when the relations prove unsatisfactory. The trade is learned just as in apprenticeship; periods ranging from three to five, or seven years are passed through, and wages are paid.

Though this holds good of all the great departments of engineering, exceptions are growing up. Apprenticeship or its equivalent is adopted in pattern-making, moulding, forging, boiler-making, plating, turning, fitting, and erecting, and to a limited extent in the machine shop. But in some departments of this shop and of others the growth of machines of some types has had the effect of displacing skilled craftsmen. It is so in the practice of the automatic screw machines, of die forging, of moulding machines. These departments are growing, but as yet they do not very seriously assail the position of the skilled craftsman.

Articled Pupils. Articled pupils are the so-called "gentlemen apprentices," who pay premiums ranging from £50 to £100 a year for the privileges of enjoying the training afforded by going through the entire course of the works departments, including the drawing office. Sufficient knowledge is gathered in the shops for an intelligent understanding of the operations performed, without much manual skill. Many, however, do acquire a considerable amount of this. But the extent of the field which has to be covered prevents a lengthy stay in any shop. The work of design gathered in the drawing office is of greater importance, and a good scientific and mathematical training are essential here. Pupils are brought into intimate relationships with the principals or the management, and so may learn much. They are also sent out on contracts in charge of erections, and thus acquire practical knowledge. They also witness tests, and may have to assist at them. There are not wanting indications that pupilage may become an institution of the past, and apprenticeship on a broad basis take its place. That is so now in a few isolated works, and it may be expected to extend.

International Rivalry. A generation ago English engineers were in the proud position of being able to ignore the trade rivalry of foreign nations. British machinery was in great demand, and British engineers and workmen were sent abroad to teach the foreigner how to design and build mechanisms. That state of things is past, and now many of our own shops are equipped extensively with machine tools of German and American manufacture. The designs and systems also in use in those countries have been imitated here. The impress of American design is apparent in many British-made tools for turning, planing, grinding, milling, gear cutting, and measurement. Very often these tools are much better, stiffer, stronger than their prototypes, but their development has been nevertheless clearly due to American influence. Ten years ago the British firms began to wake up, and copy and improve; now they enter into rivalry with their teachers. It is the same in the lay-out of works, and in the altruistic aspect of the provisions made for workmen. The modern types of works illustrated in this article are an innovation, the first developments of which grew in America. The interchangeable system also, to which reference has been frequently made in this course, is of American development. But it is now adopted in hundreds of British and German firms, for Germany, like ourselves, has borrowed from America.

Briefly, the issue now is that the three great manufacturing nations of the world have arrived at a period of intense rivalry. In a lesser degree, though only by comparison, the same holds good of the engineering products of Belgium, France, Italy, and Switzerland.

The Key to Success. Under these conditions the question of how to maintain a good industrial position — the time to talk of *supremacy* is past—becomes one of national importance. Clearly the solution lies mainly in the training of a race of capable engineers and skilful and contented artisans. How best to do this is answered in different ways. In England and America it is done mostly by a practical training in the shops, through indentured or non-indentured apprenticeship; and in the case of articled pupils, of going through the works. In Germany, technical training occupies a large and essential place. Military service also is stated to exercise a steadying effect, and to engraft habits of obedience and precision on the army of labour. The technical training is certainly reflected in the designs of many German machines in respect of the most economical disposition of materials, though this is sometimes cut too finely. Putting it very broadly, the differences in English and German design may be stated thus: that experience largely controls the first, and mathematical calculations the second. The first savours distinctly of the shops, the second of the schools. The difference is reflected in the technical literature of the two countries. English books are mainly practical; we have no original works corresponding with those of Reuleaux. American mechanics are not so hide-bound by the traditions of apprenticeship as the English are. The "one man one job" idea is not so rampant. Initiative is encouraged. Consequently the American has a chance if he is prepared to grasp it. His application is more intense, but he does not wear so long.

Technical Literature. The technical literature of engineering is rapidly becoming cosmopolitan. English journals are read abroad. They take the highest rank. "Engineering" and "The Engineer" are very solid, reliable, and representative, and are second to none in the world. The "Mechanical World" is mainly a workman's paper, and is very practical. The "American Machinist" is now known nearly as well over here as in the States. Its name exactly expresses its scope. It caters for the men in the shops, and is written mainly by workmen for workmen. "Machinery" resembles it closely. "Power" caters for the engine builders and users. Engineering is treated popularly in two excellent monthlies, "Cassier's Magazine," and the "Engineering Review." The articles are technically accurate, mostly written by experts, and up-to-date. There are, of course, other journals and magazines, but these are the best. "The Foundry" (American) is devoted entirely to the moulder's craft. "Wood Craft" treats of various woodwork, including pattern-making; this is also American. The German journal "Zeitschrift des Vereines deutscher Ingenieure" is the leading one in that country. Another excellent one devoted to machine tools is the "Zeitschrift für Werkzeugmaschinen und Werkzeug." "Stahl und Eisen" deals with foundry and metallurgical work. The "Revue Industrielle" is one of the best French journals.

THE BEST BOOKS ON MECHANICAL ENGINEERING

STEAM AND STEAM ENGINES. "Steam," by Ripper (Longmans, Green & Co., London. 2s. 6d.); "Steam Engine Theory and Practice," by Ripper (Longmans. 9s.); "The Marine Steam Engine," by Sennett and Oram (Longmans. 21s.); "A Manual of Marine Engineering," by Seaton (Charles Griffin & Co. Ltd., London. 21s. net); "Marine Engines and Boilers," by Bauer (Crosby Lockwood & Son, London. 25s. net); "The Steam Engine," by Holmes (Longmans. 6s.); "Valves, and Valve Gearing," by Hurst (Griffin. 10s. 6d.); "A Manual of the Steam Engine and Other Prime Movers," by Rankine and Donkin (Griffin. 12s. 6d.); "Steam and Steam Engines," by Jamieson (Griffin. 10s. 6d.); "The Practical Engineer's Handbook," by Hutton (Lockwood. 18s.); "Text Book on the Steam Engine," by Goodeve (Lockwood. 6s.); "A Handbook on the Steam Engine," by Haeder and Powles (Lockwood. 7s. 6d. net); "The Safe Use of Steam," by An Engineer (Lockwood. 6d.); "The Steam Engine," by Cotterill (E. & F. N. Spon, Ltd., London. 15s.); "Theory of Heat," by Clerk-Maxwell (Longmans. 4s. 6d.); "The Indicator," by Pickworth (Emmott & Co., Manchester. 3s. net); "Indicator Practice," by Hemenway (Chapman & Hall, Ltd. 8s. 6d. net); "The Indicator," by Porter (Spon. 9s.); "Slide Valve," by Welch (Spon. 6s.); "Slide Valve," by Halsey (Spon. 6s. 6d. net).

STEAM BOILERS. "Marine Boiler Management and Construction," by Stromeyer (Longmans. 12s. net); "Steam Boiler Construction," by Hutton (Lockwood. 18s.); "The Heat Efficiency of Steam Boilers," by Bryan Donkin (Griffin. 25s.); "Boilers, Marine and Land," by Traill (Griffin. 12s. 6d.); "Steam Boilers," by Munro (Griffin. 4s. 6d.); "Steam Boilers, Their History and Development," by Powles (Archibald Constable & Co., Ltd., London. 24s. net); "Water Softening and Treatment," by Booth (Constable. 7s. 6d. net); "Smoke Prevention," by Booth and Kershaw (Constable. 6s. net).

GAS ENGINES. "Gas Engines, and Producer Gas Plants," by Mathot (Lockwood. 12s. net); "Gas Engines," by Robinson (Spon. 21s. net); "Gas, Gasoline, and Oil Engines," by Hiscox (Constable. 10s. 6d. net); "The Gas and Oil Engine," by Clerk (Longmans. 15s.); "Gas, Oil, and Air Engines," by Bryan Donkin (Griffin. 25s. net); "Modern Gas and Oil Engines," by Grover (Technical Publishing Co., Manchester. 4s. 6d.).

FUELS. "Liquid Fuel and its Combustion," by Booth (Constable. 24s. net); "Producer Gas," by Dowson (Longmans. 10s. 6d. net); "Gas, Oil, and Solid Fuel," by Lewes (Constable. 6s.); "Gaseous Fuel," by Thwaite (Whittaker, London. 1s. 6d.); "Fuel, Gas, and Water Analysis," by Kershaw (Constable. 8s. net); "Oil Fuel," by North (Griffin. 5s. net); "Petroleum," by Redwood (Griffin. 2 vols.).

STEAM TURBINES. "The Marine Steam Turbine," by Sothern (Whittaker. 6s. net); "Steam Turbine Engineering," by Stevens and Hobart (Whittaker. 21s. net); "Steam Turbines," by Stodola (Constable. 21s. net); "Experimental Researches on the Flow of Steam through Nozzles and Orifices," by Rateau (Constable. 4s. 6d. net); "The Theory of the Steam Turbine," by Jude (Griffin).

AUTOMOBILES. "English and American Steam Carriages and Traction Engines," by Fletcher (Longmans. 15s. net); "Petrol Motors, and Motor Cars," by Hyler White (Longmans. 4s. 6d. net); "Motor Vehicles, and Motors," by Beaumont (Constable. 2 vols., 84s. net); "O'Gorman's Motor Pocket Book," by O'Gorman (Constable. 7s. 6d. net).

DRAWING AND DESIGN. "A Manual of Machine Drawing and Design," by Low and Bevis (Longmans. 7s. 6d.); "Elements of Machine Design," by Unwin (Longmans. Part I., 7s. 6d.; Part 2, 6s.); "A Text Book of Engineering Drawing and Design," by Wells (Griffin. 2 vols., 9s.); "Sketches of Engine and Machine Details," by Bentley (Chapman & Hall. 2s. 9d.); "Drawing, and Rough Sketching for Marine Engineers," by Donaldson (Norie & Wilson, Minories, London); "Mathematical Instruments," by Stanley (Spon. 5s.).

MECHANICS. "The Mechanics of Machinery," by Kennedy (Macmillan & Co., Ltd., London. 8s. 6d.); "The Constructor," by Reuleaux (Engineering Magazine Office, London. 30s.); "Applied Mechanics," by Cotterill (Macmillan. 18s.); "Applied Mechanics," by Jamieson (Griffin. Vol. 1, 8s. 6d.; Vol. 2, 12s. 6d.); "Mechanical Movements," by Barber (Spon); "Mechanical Movements, Powers, Devices, and Appliances," by Hiscox (Constable. 12s. 6d. net); "Rope Driving," by Flather (Chapman & Hall. 8s. 6d. net); "Dynamometers, and the Measurement of Power," by Flather (Chapman & Hall. 12s. 6d. net); "A Manual of Machinery and Millwork," by Rankine (Griffin. 12s. 6d.); "A Manual of Applied Mechanics," by Rankine (Griffin. 12s. 6d.); "Friction and Lost Work," by Thurston (Chapman & Hall. 12s. 6d. net); "Kinematics," by Weisbach (Chapman & Hall. 21s. net); "Machinery of Transmission, and Governors," by Weisbach (Chapman & Hall. 21s. net).

MATERIALS. "The Materials of Engineering," by Thurston (Chapman & Hall. In three parts, 8s. 6d., 15s., 10s. 6d. net); "A Text Book of the Materials of Construction," by Thurston (Chapman & Hall. 21s. net); "Strains in Iron Work," by Adams (Spon. 5s.); "Handy Book for the Calculation of Strains in Girders," by Humber (Spon. 7s. 6d.); "Stresses and Thrusts," by Middleton (Batsford, London. 5s.); "The Strength of Materials and Structures," by Anderson (Longmans. 3s. 6d.).

HOISTING AND CONVEYING. "The Mechanical Handling of Material," by Zimmer (Lockwood. 25s. net); "Hoisting Machinery," by Horner (Lockwood. 7s. 6d. net); "Aerial or Wire Rope Tramways," by Wallis-Taylor (Lockwood. 7s. 6d.); "The Mechanics of Hoisting Machinery," by Weisbach & Herriman (Macmillan. 12s. 6d. net); "Belting," by Halliday (Spon. 3s. 6d.); "Belting," by Cooper (Spon. 12s. 6d. net); "Toothed Gearing," by Cromwell (Chapman & Hall. 6s. 6d. net); "Helical Gears," by Horner (Whittaker. 5s.).

RAILWAY ENGINEERING. "British Locomotives," by Cooke (Whittaker. 7s. 6d.); "Locomotive Engine Running and Management," by Sinclair (Chapman & Hall. 8s. 6d. net); "Recent Developments in Locomotive Practice," by Cooke (Whittaker. 2s. 6d.); "The Working and Management of an English Railway," by Findlay (Whittaker. 7s. 6d.); "The Midland Railway," by Williams (Bentley. 12s.); "Our Iron Roads," by Williams (Bentley); "The Railways of England," by Ackworth (Murray. 12s.); "Steam Locomotives," by Pendred (Constable. 6s.); "Locomotive Engineering," by Pettigrew and Ravenshaw (Griffin. 21s.); "Catechism of the Locomotive," by Forney (Spon. 15s. net); "Modern Locomotive Construction," by Meyer (Chapman & Hall. 42s. net); "The Construction of the Modern Locomotive," by Hughes

(Spon. 9s.); "Railway Brakes," by Blackall (Spon. 8s. 6d. net); "Railway Construction and Maintenance," by Cole (Spon. 7s. 6d. net); "Railway Track and Track Work," by Tratman (Constable. 12s. 6d. net); "Light Railways," by Cole (Griffin. 16s.); "The Inspection of Railway Material," by Bodmer (Whittaker. 5s.).

BRIDGE AND GIRDER WORK. "A Practical Treatise on Bridge Construction," by Claxton Fidler (Griffin. 30s.); "The Design of Beams," by Atherton (Griffin. 6s. net); "Ironwork," by Adams (Spon. First series, 8s. 6d; Second series, 8s.); "Constructional Steelwork," by Farnsworth (Constable. 10s. 6d. net).

PUMPS AND HYDRAULICS. "Hydraulic Power and Hydraulic Machinery," by Robinson (Griffin. 34s.); "Pumping Machinery," by Davey (Griffin. 21s. net); "Hydraulic Machinery," by Blaine (Spon. 14s. net); "Hydraulic Motors," by Björling (Spon. 9s.); "Hydraulics," by Box (Spon. 5s. net); "Pump Construction," by Björling (Spon. 5s.); "Pumps," by Björling (Spon. 30s. net); "Pump Details," by Björling (Spon. 7s. 6d.); "Hydraulic Motors and Turbines," by Bodmer (Whittaker. 15s.); "Pumps," by Colyer (Spon. Part I., 28s.; Part II., 25s.); "Centrifugal Pumps, Turbines, etc.," by Innes (Tech. P. Co. 4s. 6d.); "Turbines," by Wood (Chapman & Hall. 10s. 6d. net); "Hydraulics and Hydraulic Motors," by Wiesbach (Chapman & Hall. 21s.).

MISCELLANEOUS SUBJECTS. "Lubrication and Lubricants," by Archbutt and Deeley (Griffin); "Aid Book to Engineering Enterprise," by Matheson (Spon. 24s.); "Depreciation," by Matheson (Spon. 7s. 6d. net); "Factories and Workshops," by Thwaite (Spon. 9s.); "Warming Buildings," by Dye (Spon. 10s. net); "Warming and Ventilating," by Dye (Spon. 8s. 6d. net); "Heating by Hot Water," by Jones (Lockwood. 6s.); "Hot Water Supply," by Dye (Spon. 3s. net); "Rustless Coatings," by Wood (Chapman & Hall. 17s. net); "Pipes and Tubes," by Björling (Whittaker. 3s. 6d. net); "Ice Making," by Redwood (Spon. 4s. 6d. net); "Marine Propellers," by Barnaby (Spon. 10s. 6d. net); "Workshop Costs," by Pearn (Tech. P. Co. 12s. 6d.); "Refuse Disposal and Power Production," by Goodrich (Constable. 21s. net); "Small Dust Destructors," by Goodrich (Constable. 4s.); "Compressed Air," by Richards (Chapman & Hall. 6s. 6d. net); "Steam Heating for Buildings," by Baldwin (Chapman & Hall. 10s. 6d. net).

ENGINEERS' WORKSHOP PRACTICE. "Practical Metal Turning," by Horner (Lockwood. 9s. net); "The Works Managers' Handbook," by Hutton (Lockwood. 15s.); "Plating and Boiler Making," by Horner (Lockwood. 7s. 6d.); "Pattern Making," by Horner (Lockwood. 7s. 6d. net); "Elementary Forge Practice," by Bacon (Chapman & Hall. 6s. 6d. net); "Machine Shop Companion," by Bentley (Chapman & Hall. 1s.); "Steel," by Metcalf (Chapman & Hall. 8s. 6d. net); "Machinery Pattern Making," by Dingey (Chapman & Hall. 8s. 6d. net); "The American Steel Worker," by Markham (Spon. 10s. 6d. net); "The Iron-founder," by Bolland (Chapman & Hall. 10s. 6d. net); "American Foundry Practice," by West (Chapman & Hall. 10s. 6d. net); "Moulder's Text Book," by West (Chapman & Hall. 10s. 6d. net); "Practical Iron-founding," by Horner (Whittaker. 4s.); "Moulding and Founding," by Overman (Spon. 8s. 6d. net); "Brass-founding," by Larkin (Spon. 10s. 6d.); "Brass-founding," by Buchanan (Spon. 4s. 6d. net); "Casting and Founding," by Sharp (Spon. 21s. net); "Modern Milling Machines," by Horner (Lockwood. 12s. 6d. net); "Modern Machine Shop Tools," by Van Dervoort (Lockwood. 21s. net); "Tools for Engineers and Woodworkers," by Horner (Lockwood. 9s. net); "Dies: Their Construction and Use," by Woodworth (Sampson Low. 14s. net); "Tool Steel," by Thallner (Sampson Low. 10s. 6d. net); "Text Book of Mechanical Engineering," by Lineham (Chapman & Hall. 12s. 6d. net); "Screw Cutting," by Reed (Spon. 2s. 6d. net); "Screw Cutting," by Martin (Spon. 1s.); "Punches, Dies, and Tools," by Woodworth (Lockwood. 16s. net); "Questions and Answers from the American Machinist" (American Machinist Press. 5s.); "Hardening, Tempering, Annealing, and Forging of Steel," by Woodworth (Constable. 10s.); "Dies: Their Construction and Use for the Modern Working of Sheet Metals," by Woodworth (Constable. 12s. 6d. net); "Precision Grinding," by Darbyshire (Constable. 6s. net).

ENGINEERS' REFERENCE BOOKS. "Engineering Standards Committee's Publications" (Lockwood. 31 Reports published. Prices from 1s. to 21s.); "The Naval Architect's and Shipbuilder's Pocket Book," by Mackrow (Lockwood. 12s. 6d. net); "Marine Engineer's Guide," by Wannan (Lockwood. 10s. 6d. net); "The Mechanical Engineer's Pocket Book," by Kent (Chapman & Hall. 21s. net); "French Measure," by Brook (Spon. 1s.); "Steam Boilers," by Foden (Spon. Tables. 5s.); "Steam Boilers," by Sexton (Spon. 5s.); "Whittaker's Mechanical Engineers' Pocket Book," by Björling (Whittaker. 3s. 6d. net); "Engineers' Pocket Book," by Molesworth (Spon. 6s.); "Reed's Engineers' Hand Book" (Reed & Co., Ltd., Sunderland. 12s. 6d. net); "Key to Ditto" (Reed. 7s. 6d. net); "Reed's Guide to Board of Trade Examinations" (Reed. 18s. net); "Reed's Handbook for Examination of Engine Room Artificers" (Reed. 4s. net); "Reed's Useful Hints to Sea-going Engineers," (Reed. 3s. 6d. net); "Reed's Marine Boilers" (Reed. 4s. 6d. net); "The Mechanical Engineer's Reference Book," by Foley (Lockwood. £3 3s. net); "The Engineer's Year Book," by Kempe (Lockwood. 8s.); "The Mechanical Engineer's Pocket Book," by Kinnear Clark (Lockwood. 6s. net); "Practical Mechanic's Workshop Companion," by Templeton and Hutton (Lockwood. 6s.); "A Pocket Book of Marine Engineering Rules and Tables," by Seaton and Rounthwaite (Griffin. 8s. 6d.); "Virtue's Encyclopædia of Engineering and Allied Trades" (Virtue & Co., London. In 10 vols., at 7s. 6d. per vol. 5 vols. published); "The Mechanical World Pocket Book," (Emmott & Co. Annual 1s.); "The Practical Engineer Pocket Book" (Tech. P. Co. Annual 1s.).

DICTIONARIES. "A Railway Technical Vocabulary," by Serraillier (Whittaker. 7s. 6d.); "Lockwood's Dictionary of Mechanical Engineering Terms" (Lockwood. 7s. 6d. net).

TECHNICAL DICTIONARIES IN SIX LANGUAGES. "Machinery," 5s. net; "Electrical Plant," 5s. net (Constable. Others in preparation).

MECHANICAL ENGINEERING *concluded; followed by* CLOCK AND WATCH MAKING

Continued from page 5495

TAILORS

MUCH that we have said with regard to starting in business as a clothier [page 1896] applies also to the tailor, especially with regard to the financial arrangements and the taking of the shop; but on this latter point we may note that there is not the same demand for show windows in a tailoring business that there is in a clothier's, though the drift of recent years has been to pay as much attention to the tailor windows as for any other trade. Still, the vast majority of tailoring establishments do not make a very large window display, being content to indicate their business, and place on view a few leading lines; and after all, window tickets and rolls of cloth do not convey much idea of the finished garment to the average customer.

Capital. The capital required for a tailor to start business does not differ much from that of a clothier, for though he seldom has to keep such a large stock, yet he has to pay for a large proportion of the goods he produces in prompt cash in the form of wages. It is often much more difficult for him to get ready money for his goods when they are completed. The terms of credit allowed by the woollen warehouses are generally of an easier character than the clothing houses, and in some case very long credit is given. It may, however, be taken for granted that the man who has £200 to £250 may start in business as a tailor with every prospect of success if his general ability be equal to his cash.

Shop Fitting. The fixtures may be of the simplest nature, just plain shelves, with turned bars to act as divisions. The shelves should be about 18 to 20 in. apart. A counter not less than 30 in. high and about the same width should be arranged of convenient length.

A private room should be provided for trying on, and in this there should be mirrors arranged so that both back and front views of the figure can be obtained if desired. The fittings of this room may be amplified to taste. There must, of course, be one or two chairs, but there may also be blocks for saddles, etc., which are especially useful in the case of riding garments; a selection of framed fashion plates are also very useful here. A cutting table must be provided, and this should be of a substantial character, as it will be subjected to a good deal of hard wear; it should be 30 to 36 in. wide, 33 to 36 in. high, and if possible 10 ft. 6 in. long. The light should be sufficient for all practical purposes, but there is no need for that big blaze of light which characterises the premises of the clothier and draper, and which involves a heavy expense.

Workshop. The tailor must decide whether he will have his garments made up in his own workshop or at the worker's house; there is no doubt that the former plan is the better, if it can be arranged. If he has a workshop on the premises, there should be a broad bench provided from 20 to 30 in. high for the men to sit on, a sewing machine with wide table, a stove for heating the irons (coal stoves are undoubtedly the cheapest), a selection of irons from 10 to 20 lb., sleeve-boards, duplex press boards, iron stands, bowl, etc., etc.

The light must be arranged of sufficient quality and quantity for each worker to see well, and there is no doubt that most journeymen tailors prefer the old batswing gas burner to any other form of light. This is due mainly to prejudice, and those who have used the electric light prefer it. The best workshops in London are provided with electric light. There must be rails and coat-hangers, stools or chairs for the machinist and any female workers, and a few other sundries which will suggest themselves.

Stock. Stock should consist of pieces or ends of such cloths as are in constant demand, as, for instance, a medium quality blue serge, black vicuna, etc., ten-yard lengths of hairline and neat pattern tweeds, for which there is a good sale, and for the rest a good variety of suit lengths (3 yd. double-width), trouser lengths (2½ yd. narrow width), coat and vest lengths (2 yd. double-width), and a few fancy waistcoat lengths (¾ yd. narrow).

The cloths purchased in this way should all be safe patterns, relying upon pattern bunches for those louder designs which are wanted only occasionally, and which are often very risky. In addition to a stock of cloth, a fair supply of trimmings will be necessary, and must include Italian cloth and silesia, two qualities in black, one quality in two or three shades each of grey, brown, drab, etc.; linen in black, grey, brown, and whitey brown; canvas in two makes, French and flax, in drab and black; interlining for vests—striped silesia or sateen in two or three qualities; a good assortment of buttons in coat and vest sizes—twice as many of the latter as of the former; trouser buttons with the name stamped on; buckles; and a good assortment of twist, silk, threads, cottons, etc. Special items of trimming can be obtained to order more economically than by stocking quantities.

Side Lines. Many tailors keep an outfitting department, selling such articles as braces, ties, collars, shirts, studs, umbrellas, rugs, and bags. There are plenty of wholesale houses in the neighbourhood of Wood Street, London, that supply goods of this sort in suitable quantities; and as such goods yield a very fair profit, they are generally worth stocking. It is not necessary to keep a large stock of these, as anything not in stock can be obtained in a couple of days. On the other hand, if goods of this description are to be sold at all, they should be stocked in sufficient variety to meet the requirements of customers.

Profit. The rate of profit charged must necessarily vary with the class of trade, for not only has the question of cash and credit to be considered, but also the probability of the customer returning the garment for alterations. Let it be clearly understood that the majority of alterations are made to meet customers' whims, and are by no means caused by the tailor's fault. In calculating the cost charge for:

	s.	d.	
Materials, say ..	7	6	
Trimmings ..	1	0	
Making	3	6	
Cutting ..	1	0	
	13	0	cost price.
For cash trade add 25 per cent. on returns:	4	0	
	17	0	selling price.

For credit trade add 33⅓ per cent. on returns, thus:

s.	d.	
12	0	net cost
6	0	profit
18	0	selling price.

For high-class credit trade, with many alterations, etc., add 50 per cent. on returns:

	s.	d.	
	12	0	net cost
	12	0	profit
£1	4	0	selling price.

Now, the tailor must not imagine that the amount added to the nett cost is all going into his pocket as profit, for out of it has to be paid the cost of alterations, working expenses, rent, etc., In calculating profit it should always be done at so much per cent., and should always be on the returns—that is, the amount received—so that a business yielding a profit of 25 per cent. would be making a gross profit of £25 out of every £100 taken, and in order to do this the proportion added must be one-third.

Advertising. In advertising a tailoring business it is necessary to emphasise the fact that every effort will be made to carry out the customers' wishes; that the talent employed in the cutting and fitting rooms is such as will enable goods to be supplied that will fit and be stylish; that the materials sold are reliable in both dye and quality, and that the workmanship is such as will give good style and enable the garments to stand the test of wear.

If it is intended to make a special lead of any department, then prominence should be given to it, and this is easily done by issuing charts of fashions, which must, of course, portray the most up-to-date styles. Above all it must be borne in mind that while printer's ink is an excellent advertising medium, it is nevertheless far inferior to the personal recommendation of a pleased customer, so that it should be the tailor's aim at all times to send every customer away thoroughly pleased and satisfied.

Judging Cloths. Unless he is to be very much at the mercy of those from whom he buys, the tailor must cultivate an independent judgment of the merits of cloths. The matter is one on which each has his own ideas, even if they be not the right ones. But, fortunately, it is well within the compass of anybody to assimilate a set of standards that will be helpful in arriving at a right understanding. It is out of the question here to deal with matters of styles, for fashion is constantly changing those. A certain dominating trend of taste remains, which varies with localities and with classes of customers rather than with time, and these canons can be learned only by close observation in one's own circumstances. The considerations governing one's opinion of the relative value of goods and of the likelihood of their giving satisfaction to customers are more universal. It is true that no single test is perfectly conclusive; it is for buyers to take one consideration with another and to deliver judgment on the balance of the evidence. They have to remember also that price is not a fixed criterion. Owing partly to different systems of manufacture and partly to trade custom, different cloths of very different values in wear are offered at approximately the same prices.

Weight of Cloth. Weight is a major factor in determining a cloth's value. Other things equal, a cloth weighing 22 oz. per yd. will cost more than another of 18 oz. In dealing with plain black and blue cloths, and keeping a sharp eye on the quality of the patterns compared, it is possible to reduce comparison to a simple calculation of so much per oz. per yd. That process does not hold good absolutely where the more complex cloths and fabrics of differing material are concerned. Yet it must always be of moment to observe that the weights either are or are not in agreement. It becomes a question of ascertaining whether the quality is better or worse, and the feel, the so-called "handle," will tell much. Generally speaking, the softer and finer wools are the most costly, the harsher and coarser the cheaper. The natural handle of a wool fabric may be more or less falsified by its "finish." Manufacturers give a sharp or a soft finish as is required, doing so chiefly by greater or less pressing between hot plates. Too smart a finish is not usually desired, and one of the advantages of having goods "London shrunk" is that any unnatural asperity is removed at the same time that the cloth is made unshrinkable. It goes without saying that all purchases should be made on the understanding that the cloths are shrunk fully.

Analysing Cloth. Touch will tell whether the cloth's structure is firm, and if it be flabby the probability is that garments from it will lose their shape quickly. To go further into the problem of quality it will be necessary to attack a raw edge either with finger-nails or tweezers. The main components of the fabric are then exposed—the warp or lengthwise threads, and the weft or crosswise threads. Holding short lengths of these yarns to the light and unrolling them under the fingers, one may see whether they are single threads or twofold, or threefold. In most cases "folded" yarn is to be preferred for hard wear, and in most cases it is the more expensive. The detaching of a thread or two at right angles to each other will show whether the material is close-set, and with a "piece-glass," obtainable from opticians, the number of threads per half or whole inch in either direction may be counted. It is well to select a fabric with many threads in the warp, and—by means detailed later—to see that these threads on which the greater strain is put are strong. Having isolated these bits of yarn it is possible to examine them further. If there is any suspicion that one of the threads is cotton, that point can be decided immediately by use of a flame. Cotton burns, and a flame applied to a cotton thread will creep in a bead along its length. Wool and silk, being animal products, swell and char under heat, and do not convey fire.

The thread being wool, one proceeds to see whether it is woollen or worsted. Fabrics wholly

of the latter are liable to grow shiny in wear, although their general durability is excellent. If the cloth be woollen its threads will be found matted one to another more closely than in worsted. And in unravelling the bit of yarn it will be seen that in woollen the ultimate fibres lie criss-cross and that in worsted they run parallel with each other. Woollen yarn is the vehicle for carrying any shoddy there may be present, but to discriminate with absolute certainty between long shoddy and short wool baffles experts. Inferior shoddy is readily detected by the extreme shortness of the fibres, which crumble out as the yarn is unrolled. In a similar fashion they work out and create fluff in wear, leaving the garment thinner and shabbier. In the best woollens the fibres disclosed will be fairly uniform in length, neither very long nor very short, and of fine calibre. In the best worsted the filaments are very long, and by the fineness of their diameter the quality of the wool is to be measured. The eye can discern these differences in dimension, although, expressed in fractions of an inch, the variation might seem infinitesimal.

Testing Strength. Having compared the weight and build and components of two cloths, it falls to examine their strength. The Governments use apparatus to record the breaking strain of the fabrics they buy, but a rougher test is dependable. It emphatically is not the way to test strength to seize a raw edge and endeavour to tear it with all the might of one's arms. The cloth should be held under the two thumbs, which ought to be pressed together above the clenched fists. A bursting strain is applied, for while pressing down with the thumbs the fists are edged away from each other to form an inverted V beneath. If it is possible to break the fabric in this way its strength is inferior. If it is possible to stretch or make the threads slip, the sign may not be fatal although it cannot be thought advantageous. The force needs to be applied in two directions, to test warp as well as weft, and it is of high importance that the warp should bear such usage well. Otherwise, split trouser knees and elbows may be confidently foreseen. For the sake either of cheapness or to secure a soft surface, weft of no great resisting power is left to depend on a stronger warp in order to give satisfaction to the wearer.

Wearing Qualities. These are not the only points to consider. Cloths may be examined to see whether they will wear through alike or whether their utility is over as soon as any portion of the face is done. Whenever wool is dear there is an irruption of " backed " cloths with shoddy interiors which give nothing but weight and warmth. Apart even from the technical facts of cloth structure many members of the public are prejudiced against fabrics which have not both sides alike. It is readily possible to found too much on the observation that a cloth is opaque or reveals some interstices when held before a strong light. Density is an occasional source of discomfort in summer, although opaque fabrics are usually better protection against rain. Hygienists are of the belief that clothes, like houses, should be ventilated, and it is by no means impossible to combine all the textile virtues with a modified permeability to air. The fact, therefore, that a cloth is porous, like the facts that it is thick or thin, soft or hard, needs to be taken in its due perspective and not as a final indication by itself.

Fashion brings into periodical vogue cloths with trailing hairs upon the surface. The ease with which these hairs may be dislodged with the fingers indicates fairly plainly how soon they may be expected to disappear in wear. There are frictional tests of exactitude to apply to fabrics of a sort scarcely practicable by private firms or individuals. However, it will often be of advantage to scrub the surface of cloth with a scrap of hard, white writing paper. An objectionable habit has grown up among manufacturers of recent years of " grease-dyeing " black and blue worsteds. To save an ounce of wool to the yard, an ounce of grease is left in the fabric and this is betrayed by an oily smudge upon a piece of clean paper. In the case of cloth stated to be indigo dyed, and more especially if it be called wool-dyed indigo, the use of paper is again advisable. No blue colour is so permanent as indigo, but it has the inalienable paper defect of rubbing off. The more it marks the paper or the wearer's linen collar blue the more probable is it that it is indigo, and wool-dyed indigo at that.

Chemical Tests. To go further into proof of the presence either of grease or of indigo leads to a little mild chemistry. By means of benzene the amount of grease in a fabric might be estimated accurately with a delicate pair of scales. Testing for indigo involves merely the use of a spot of nitric acid. If the effect of acid on the cloth is to turn the blue to lemon-yellow, around which a halo of green subsequently appears, the presence of indigo is certain. If the blue turn a deeper yellow with a rim of red, it may be concluded that the dye is alizarin and nearly but not quite, as reliable as indigo. Further resort may be made to chemistry in assessing the value and composition of cloths. By boiling a piece in a strong solution of caustic soda you dissolve all its wool or silk and leave its cotton behind alone. Alternatively, by boiling the pattern in a 10 per cent. solution of sulphuric acid in water, and by leaving it afterwards to dry in low heat, you char away its cotton, leaving only the wool. These tests for wool are meaningless when applied to sound goods, although they expose in the most telling way the weakness of adulterated articles. For example, after extracting the wool from an " all wool tweed " at about a shilling the yard you may find 90 per cent. of cotton remaining.

Colour of Cloths. Many other tests, chemical and physical, may be applied by men of leisure and of training. The retailer has hardly the opportunity to expose patterns to twelve months' rain and sunshine, as some manufacturers do, upon boards hanging outside the mill. Yet he has the opportunity to observe that certain colours are especially treacherous. Browns, although they be dark, are not necessarily strong enough for the glare of a shop window. Slate shades, light blues, and greens are to be mistrusted, because in fading they leave muddy neutral hues behind. Care may be exercised in commending these to customers, in exposing those that may be in stock, and in buying further supplies. On the whole there can be no question that the manufacturers and merchants who feed the private tailor with cloths are sincerely wishful to befit their goods to the purposes for which they are intended. In using their cloths for other purposes, or in departing from the well-known channels of supply, the tailor especially needs to make full use of his best judgment.

TELEPHONE CALL OFFICES

Tobacconists, stationers, hairdressers, and, indeed, many other shopkeepers, can easily arrange—assuming that they are in suitable localities—to make the telephone a source of revenue. This remark applies with special force to London. Any shopkeeper in London may rent from the Post

Office or the National Telephone Company a connection on what is called the *message rate.*

The subscriber agrees to pay £5 per annum, and deposits 30s., which covers the cost of 360 calls at a penny each. Subsequent calls are charged at the same rate, but 30s. per annum is the minimum amount for message fees. This rate applies to exchanges within the County of London, and the penny fee covers communications all over that area, as for instance, from a Central subscriber to a Hampstead or Western subscriber, or from a Gerrard to a Putney subscriber, and with unrestricted intercommunication over both Post Office and National systems. There is no charge for calls *received* from other subscribers.

The Instrument. The shopkeeper may arrange to have his telephone placed in such a position that his customers may have easy access to it, and if he can give them some security from overhearing, so much the better. A wall instrument should be chosen, as being the least liable to faults. The shopkeeper should procure a swing sign with the legend, "YOU MAY TELEPHONE FROM HERE," or "PUBLIC TELEPHONE," and have it placed over the door of his shop, and he may then proceed to allow the public to transact their business over his instrument, charging them any fee he may care to fix. In London, the usual fee is twopence, this being the charge made by the Post Office and National Company at their own call offices, and in busy localities it is found to yield a fair margin of profit. It must be remembered that the subscriber takes all responsibility. At the exchange his calls are metered electrically, and periodical accounts are rendered to him.

Penny-in-the-slot Instruments. In some cases, to avoid keeping accounts against the exchange, the call office subscriber rents a coin-collecting box at 30s. per annum, and into this the caller is directed by the operator to place a penny on making a call. As the telephone administration collects only for itself, this means that a separate charge, say for access to the instrument, must be made. This plan does not work so well as the first, besides being slower and somewhat complicated.

The exchange will, on demand, connect callers through to exchanges which are *outside* the County of London, but *within* the London telephone area (which covers over 600 square miles), such as Ealing, Richmond, Croydon, Enfield, Redhill, Sutton, etc., but for these calls the message rate is twopence. At post-offices and National Company's call offices no distinction is made in charging callers in these cases, the ordinary twopenny fee still applying. The shopkeeper may—and generally does—follow the same practice, thus taking no profit. Such calls should be noted, to avoid misunderstanding when the account for calls comes in.

Exchanges Out of London. At the exchanges outside the County of London, already referred to, the annual rental is £4. The same deposit—namely, of 30s.—must be made, but only the calls to subscribers on the same exchange are charged at a penny. All others over the whole London telephone area are twopence. The conditions here are not so favourable for profit, but nowadays every shopkeeper finds the telephone indispensable, and even if under these conditions the profits be meagre, there is often gain which cannot be shown, in the shape of people who come in to telephone and remain to purchase.

In the Provinces the rates vary, but are generally lower, while the usual call office fee is one penny for local calls. Where the message fee is in existence, any subscriber may set up a call office; but generally speaking, as in the case of outer London, there is not a large margin for actual profit, and gain is looked for in the shape of additional customers.

In many cases, both in London and the Provinces, the National Company arrange with shopkeepers to install one of their silence cabinets, with automatic coin box, paying, in some cases, a small rental and allowing the shopkeeper to *receive* calls. In this case, the main inducement is the added customers expected, and shopkeepers who prefer this system apply to the company and make the best terms possible if the company incline to consent. Post Office silence cabinets are installed only at post-offices. In the case of sub-offices a small annual rental and commission on each call is paid to the sub-postmaster.

TOBACCONISTS

The annual licence to sell tobacco by retail costs but the modest sum of 5s. 3d. The trade itself, as often conducted, demands no great skill or experience, and it is but natural that many people without either should turn to this trade as a means of livelihood, or of ekeing out the profits of another business such as that of a hairdresser, grocer, newsvendor, confectioner, or publican. The publican's tobacco licence is held for the same period as his spirit licence; when held apart from such a licence, that to sell tobacco and snuff is renewable in July each year. It is unnecessary, perhaps, to point out that while the trade is so easy of entrance that even young women and widows practise it, this very fact exposes the beginner to all the more competition. Moreover, in most towns very smart shops are now run by companies and firms which have reduced the business of retailing, and certainly their window-dressing, to a fine art.

Starting Business. Since some tobacco shops are the smallest of all shops, while others are among the most brilliant and imposing, there is obviously a very wide range of choice. The kind of shop, however, will depend greatly on the neighbourhood and the class of customers likely to frequent it. Costly fancy goods and high-priced cigars and pipes, which are the most remunerative portions of a high-class tobacconist's stock, would be quite out of place in a shop where the customers are likely to belong solely to the artisan class. Having selected his "pitch," the intending tobacconist will probably lose little time in studying the advertisements of the trade papers, such as "Tobacco," or the "Tobacco Trade Review," and he will therein discover the existence, both in London and the provinces, of obliging firms who will supply him with "mixed parcels" of goods at almost any figure he cares to name. Of "proprietary" goods there is a bewildering variety from which to select; it would be well to try to learn the tastes of the expected patrons as far as possible before buying any large stock.

The Shop. In a tobacconist's shop the window is of primary importance. Most of the up-to-date windows are of plate-glass and occupy the whole front with the fascia. To facilitate dressing, the whole window fitting is sometimes removable, or made to revolve. Plush-covered shelving is much used for the attractive display of pipes, cigar-holders, silver goods, etc.; and mirrors at the back and sides usually assist the effect greatly. The beginner will find it worth while to pay a visit to London or one of the larger towns in order to inspect specially the tobacconist's windows and their arrangements. Very much

depends on a bright window display; the duller the neighbourhood the greater the contrast and the effect thereby gained. In dressing the window it is well, if possible, to show loose tobacco; for cigars and cigarettes dummy boxes or packets can often be used to save the deterioration of stock. For the interior of the shop a few nice-sized shelves will be useful, and have in the counter some good-sized drawers. For storing tobacco a light, well-ventilated and dry cellar is desirable, the leaf being kept in wooden casks or glazed earthenware jars with loose tin lids. In the shop the tobacco most in demand may be placed in the counter drawers, which, if not of hard wood well planed, should be lined with zinc. Cigars require different treatment and a higher temperature. If the shop itself is fairly well heated they may do on the upper shelves; but at the seaside a proper stock-room, however small, will be needed to save them from the destructive effects of the salt, humid air. Such a room should have, if possible, boarded walls, not damp and clammy stone; and artificial heat may be provided by steam pipes or by a syphon gas-stove consuming its own fumes. Where a room is not available a suitable stock-room of small dimensions may sometimes be partitioned off at the back of the shop.

Treatment of Stock. With cigars the great thing for the retailer's attention is their proper "conditioning"; with tobacco, the avoidance of mildew. Both these depend on proper storage. British cigars, of which an ordinary stock will comprise perhaps 75 per cent., are seldom sent out "conditioned" by the manufacturers, though the wholesaler may complete the process before the cigars reach the retailer. To condition them, cigars, after leaving the factory, have to be subjected for several weeks to a temperature not less than 60° or more than 80° F. Though the outer wrapper may seem dry and may crackle when pressed between the fingers, and though the ends may be brittle—the signs of a conditioned cigar—the "filler" inside may still be sappy and damp. Even a bad cigar may be improved by conditioning. For this process steam heat is the best; to allow the cigar-moisture to evaporate under the heat it is well to prise open the lids of the cigar boxes a little, or else to bore in the boxes a few gimlet holes, taking care, of course, not to injure the cigars. The great importers of Havana cigars—which everyone knows are the cigars *par excellence*—keep them in London in a constant regular temperature of about 65°. Speaking of Havanas (spelt Habana in Spanish) it may be mentioned that the colour-marks are as follow: "Claro," very light, very mild flavour; "Colorado claro," light and mild; "Colorado," brown medium; "Colorado maduro," dark brown and full flavour; "Maduro," dark and very full flavour.

Quality of Cigars. But it is said to be a mistake to suppose, as many smokers do, that the very light cigars are necessarily the mildest. The properly matured leaf, which smokes milder, is also a little darker than the immature leaf, often used for wrappers on account of its light colour. When the plant is perfectly matured before cutting, the leaf, although there are light and dark shades of it, is generally of a rich brown colour, and experts aver that such wrappers, when properly worked, will have a sweet and mild taste, even the darkest colours. A retailer samples his cigars by smoking one taken from the second layer in a box, and also by running a sharp penknife down the centre of another to learn the character of the inner wrapper and the "filler." In the smoked cigar the ash is not an infallible sign, though a white ash is usually good (especially in the cheaper lines), and grey inferior; but whatever the colour there should be regular burning. The better class of cigars should have a dull, slate-coloured ash, and should crackle crisply when gently rolled along the palm of the hand.

Precautions Against Mildew. With regard to tobacco, mould is a great enemy to the "rolls" and "cuts," and any leaf that is moist. When tobacco parcels are received they should be opened and inspected without delay, and if not found satisfactory returned promptly to the manufacturer; if only a little heated, turning over and airing may be all that is necessary. The amount of moisture in the tobacco being strictly fixed by the law, it may be presumed right in this respect when received from the manufacturer; and the retailer's problem is to keep it so, preventing loss to himself by evaporation and avoiding the opposite error of forbidden moisture. Evaporation may be prevented by covering all tobacco each night with a double thickness of canvas wetted on the upper side, the tobacco being turned over with the hands next morning; or if the tobacco gets too dry the outside may be sprayed with pure cold water applied by a diffuser such as is used for perfume, but care must be taken against overdoing this. Tobacco kept in casks should be turned over and shaken every day or so to prevent its becoming sodden at the bottom and generating the heat which produces mildew. The same applies to the earthenware jars. Every ten or twelve days or so empty and inspect these receptacles, and note carefully whether any tiny white specks—the fungus of mildew—are scattered through the tobacco. Your jars should be carefully wiped out with a coarse cloth; and the empty casks—the contents may be temporarily placed on a sheet of brown paper in the cellar—should be cleansed by a blaze of paper, followed by the application of the dry cloth. Roll, cake, etc., are less likely to become mildewed, olive oil being used in their manufacture; where any sign is found a little Lucca oil should be applied with a soft brush. Note that the quantity of oil, like moisture, is strictly limited by the law. Cheap tobaccos, which "go off" quickly are sometimes kept in galvanised iron buckets, which can be turned out and easily brushed clean every morning. Packets of tobacco, now so largely sold, should not be stored in a damp place; usually the shelves under the counter will serve for this purpose. For "smalls," which accumulate in weighing up, and so on, keep a special receptacle, and from time to time return the contents to the manufacturer, who will allow for them. Every retailer should endeavour as soon as possible to sell his own "mixtures." To collate these is no very difficult task, or they may be had ready-made from the manufacturers.

Pipes and Fancy Goods. In the selection of these the tobacconist should aim at showing a stock that will be representative and comprehensive of whatever his clients are likely to require, remembering that unsaleable stock, even though it may show a good profit, as these goods often do, is capital lying idle. Without going into detail, we cannot do better than recommend the beginner to study the catalogues and lists of special assorted parcels that are sent out by various sundriesmen in the trade. In these lists will be found full information also as to terms and discounts.

Side Lines. The side lines most commonly run in connection with the tobacconist's business are walking-sticks, which often pay very well, especially in seaside or other tourist towns, newsagency, hairdressing, stationery, cutlery, fancy china, leather goods, etc. It is necessary to bear in mind that when heavily plated articles are sold a plate-dealer's licence may be required. For gold above 2 dwts. and under 2 oz., or silver above 5 dwts. and under 30 oz., a licence costs £2 6s. Expensive sticks and the better class of cigars and cigarette cases, etc., may come under this head; but it is just these high-priced goods that, as a rule, return the retailer his highest profit.

Legal Notes. Mention has been made of the restrictions imposed by the law upon the quantity of water and oil permitted in tobacco. Another point to be remembered is that "Cavendish," or "Negro-head" tobacco, which has to be manufactured in bond, is supplied to the retailer in packets bearing the Government stamp, and this stamp has always to be obliterated when the packet is sold. Care must be taken, however, not to break the packet until it is sold, as this is not permitted by the Excise regulations. Note that the Excise officers have the right to enter and inspect the contents of any place licensed for the sale of tobacco, and if adulterated tobacco is found on the premises, or if any tobacco or snuff is wilfully concealed, the tobacconist renders himself liable to a penalty of £200 and forfeiture of the goods.

TOY MERCHANTS

The retailing of toys and games may be divided into two classes. In the one case, the stock would be made up of comparatively inexpensive articles, and would not cost a great deal to purchase; in the other, the department would include outdoor games and expensive indoor apparatus, such as billiard tables, bagatelle boards, phonographs, lanterns for enlarging, cameras, and, indeed, all the paraphernalia which are required for recreation and sport. The first class affords a capital opportunity for ladies desirous of starting in business; the second would require the superintendence of someone with expert knowledge of the rules which govern golf, tennis, cricket, football, billiards, and the rest. [See Sporting Goods Dealers, page 5343.] Indeed, from £300 to £500 might easily be sunk in this class of stock, which is listed at prices carrying a range of discounts from 15 per cent. in the case of billiard tables, to as much as a third in the matter of tennis rackets, cricket bats, etc. Moreover, this side of the business requires rather large premises, or at least a good shop-front, and a light, open showroom behind. It cannot be conducted without a moderate amount of local advertising, and even if the proprietor is in a quite small way, the salary of at least one assistant would have to be met, unless the proprietor lives on the premises and is prepared to be tied to the place during business hours. Thus, assuming a sporting games stock of £500 can be turned over three times in a year, and taking the average discount as 25 per cent., the gross profits would be between £350 and £400, out of which all expenses, including rent and rates, would have to be met before the proprietor began to take his profits. It will be seen, then, that a young man with a small sum to invest will find in this business an opening which will return him a moderate income. Of course, a £1,500 return is by no means the limit possible, especially if in time the proprietor can add cycles or sporting games, or both.

Our immediate concern, however, is with toys, in the more generally accepted definition of the word. This, as has already been pointed out, is a business which appeals to women. It can be carried on in comparatively inexpensive premises; a hundred pounds' worth of stock goes a long way towards making a brave show, and success does not depend upon a large population. There are children everywhere, and therefore customers.

Stock. The stock to fill a shop of good class, such as we have in mind, would not cost much more than £100. Practically, the whole of it would be purchased at prices which represent from 25 per cent. to 33⅓ per cent. off the selling price. It would be subdivided into a variety of sections, appealing to different ages. First, there would be toys to retail at from 1d. to 6d., the kind of things that we associate with Christmas-trees at year-end parties. Penny toys cost from 7s. 6d. to 8s. 6d. per gross; toy picture-books, 2s., 2s. 8d., 4s., or 8s., as they are intended to sell at 3d., 4d., 6d., or 1s. respectively. Dolls, for which there is a steady sale, carry similar profits at from a penny apiece upwards.

For older boys and girls every season brings with it a fresh batch of games for the table. Outdoor sports in miniature, which are not always successful copies of the original, sell freely at all times, including table bowls, croquet, etc. Besides, there are old-established favourites for the table, such as Halma, draughts, race games, Ludo, not to mention chess and backgammon.

Cards and Card Games. For all ages there are cards, comprising bridge, whist, bezique, patience, etc., which are sold under a Government stamp, and dozens of others, including snap, happy families, and other old-fashioned games which refuse to be counted out-of-date. Besides, a number of new ones, some of them of American origin, have sold freely in recent years. Most of these are sold in various editions, costing from 6d. to 3s. per pack or set, which prices also carry a discount of from a quarter to one-third.

Mechanical Toys. These sell like hot cakes, and if a group are arranged to run in a window during business hours, a crowd is always to be found round the retailer's shop-front. We stopped the other day in London before a shop near Liverpool Street Station, and counted no fewer than 17 interested youths in front of a window less than 6ft. wide. The attraction was a small hot-air engine, costing 35s., which was driving a small counter-shaft. This in turn drove other shafting on brackets (1s. 9d. each), variously disposed on two levels behind the glass. From these were driven tiny models of drilling machines, saws, cranes, hammers, and other tools and machines, the most expensive of the lot being only 9s. Motor-power can be furnished by hot-air engines at from 5s., steam engines at from as low as 6d., or from electric motors to retail at from 1s. 6d., and supplied with current from batteries costing the public no more than 1s. each. The variety of mechanical toys is remarkable, and behind all those which have been mentioned are trams and rolling stock, operated by clockwork, steam, and even the electric current on the three-line plan of the District Railway. In this department, again, discounts run ordinarily to a third.

Salesmanship and Buying. Selling toys requires patience and a pleasant manner. Children are not attracted by the typical business face and bearing. They not unreasonably and quite unconsciously assume that selling toys is as interesting as buying them, and success comes only to those retailers who can win the goodwill of the little folk,

Sixpence to many a child is a little fortune, and not to be spent without first weighing the relative merits of many articles. Even parents are difficult to please in this matter, with the result that what appears to be a simple matter is really one calling for no little tact and courteous attention.

Buying, of course, calls for care, and a due recognition of local circumstances and the seasons. In most big centres there are large warehouses where novelties can be seen and stock selected. The chief of these are to be found in Houndsditch, in London. A visit to these centres twice a year will afford better opportunities of replenishing stock than haphazard purchasing from travellers or by post from catalogues, in which the descriptions of the stock are ordinarily more artistically adorned than accurate.

UMBRELLA MERCHANTS

To-day the umbrella or the walking-stick is a necessary portion of every well-dressed man's equipment, and this trade is consequently an important one. Umbrellas were first made with long handles and ribs of whalebone or cane. The covering material was either oiled silk or cotton, until gingham was introduced, to be replaced largely by alpaca, patented by William Sangster, in 1848. Nowadays the covers are mainly silk, or silk mixtures under various names, but black and green gingham covers are yet to be obtained. The "Paragon" rib, patented by Samuel Fox, in 1852, revolutionised the industry, for this form of rib is now almost universal. It is formed of thin strips of steel rolled into a U, or trough section—a form which gives great strength to the metal, and which is said to have been suggested by the tubular bridge over the Menai Straits. As the years go by, umbrellas become more elegant and their use increases annually. The brass tubes once used for sticks are now replaced by japanned iron and steel, everything for lightness, compactness, and elegance being the desideratum. The universality of the walking-stick is likewise a feature of modern civilisation, so that as a career for an experienced man the retailing of these articles affords a promising prospect.

The Practical Part. As in every other business, practical experience is required. Umbrella re-covering and repairing is a necessary adjunct to every retailer's business, so that the man or woman who wants to succeed must know all about the mechanism of an umbrella. Of course, the whole of the umbrella cannot be made by the ordinary seller. The sticks are bought ready-made and the making of the "furniture," which includes the runner cap, the ferrule, the wheel or top-notch, the stretchers, the ribs, the top and ball-tops. the collars, the swages, and the bag slide, or cover, is in each case a separate trade. It is the "putting together" of these different parts that constitutes the experience required of an umbrella dealer. It is rather extraordinary to contemplate the number of trades engaged in the preparation of an umbrella.

Umbrella stick-making is mainly in the hands of a few large London firms, and machinery is much used. First comes the preparation of the sticks. This is done by men who straighten or twist the sticks into the shapes required in the manner described later on. By far the largest number of sticks (for umbrellas, sunshades, or walking-sticks) are natural growths, saplings of trees or climbing plants. These are preferred to sticks like ebony, boxwood, partridge wood, etc., that are cut from the solid wood. For the latter, steam power is much used, for with the aid of band and circular saws, planes and rasps, working by machinery, sticks of the toughest description can be converted into marketable commodities in a very short time, and in wholesale quantities.

Making the Umbrella. After the stick has been pruned, cut, and straightened it is passed on to the mounters. This branch of the trade is again subdivided, for there are cutters, finishers, chasers, and polishers who make and affix the silver or gold mountings or add other adornments. Walking-sticks, umbrella handles, and parasols are mounted not only in gold and silver, but in tortoiseshell, and Mexican onyx, agate, jasper, various marbles, and even diamonds, being sometimes employed in this branch. Then handles of ivory, or horn (rhinoceros, buffalo, stag, seahorse, walrus tusk) are prepared, polished, and fitted. The frames, ferrules, collars, etc., are obtained from manufacturers of these articles, but men called frame-makers are employed in the City warehouses to put the frames together, while other workmen known as fitters, add the ferrule and other furniture. There are other men who cut the segments of silk, silk and alpaca, or other covering, into the requisite shape for fitting over the frames. Experienced cutters earn from 25s. to 35s. per week, while frame-workers and finishers get from 20s. to 32s. per week, working either by time or by the piece. The machining of the shaped segments and "tipping" or attaching the covers to the frame is usually done by women at their own homes. The silk, alpaca, cotton, or whatever it may be, is folded in eight thicknesses, which the men cut into the eight bulging triangles required for the umbrella. These covers and frames are then put together in dozens and given out to the home workers who machine the different parts of the cover and put them on the frame. The class of umbrella finisher varies with the class of umbrella, the cheapest and worst being made by Jewesses in the East End of London. The best work in the East End is on parasols, the women being paid at the rate of 1s. 3d. to 1s. 6d. each parasol, but rates even down to 1s. per dozen prevail. Some warehouses employ women finishers on the premises. They are better paid, and "table hands"—those who finish and trim parasols of the best class for the West End—make from 10s. to £2 per week, according to their skill. The earnings vary greatly according to the season, the busy seasons being from March to May for summer goods and from August to October for umbrellas.

Walking-sticks. As mentioned in a previous paragraph, the sticks most popular are those of natural growth. Some, like ash, birch, blackthorn, crab (crab-apple), dogwood, elm, furze (whin or gorse), holly, hornbeam, maple, mountain ash, oak, thistle (really mullein), and whitethorn are indigenous to the United Kingdom, but the greater part are imported from various parts of the world. There appears to be scarcely a limit to the material that is turned to account for the purpose of making sticks for umbrellas and walking-sticks, and many Continental countries have taken up the cultivation of sticks of certain kinds for the sole purpose of supplying the walking-stick market. Large numbers of ash saplings in which all the roots have been directed one way to form what is known as "cross-heads," have been grown in Surrey. But the following list of the natural products used for sticks and umbrella handles will show that we find variety in the saplings grown by countries other than our own.

Those products already mentioned are not included in this list, which indicates the countries of origin.

Acacia (Africa and Australia)
Bamboo (China and Japan)
Bakow (Singapore)
Bay-tree (Algeria)
Beefwood (Cuba)
Black Tork (West Indies)
Boxwood (Persia and West Indies)
Briar (West Indies)
Carob or Caroubier (Algeria)
Carolina Reed (China)
Cedar-wood (North America)
Cherry (Austria and Hungary)
Chestnut, Spanish (France)
Coffee (West Indies)
Cork (Spain and Algeria)
Date Palm (Algeria)
Ebony (Ceylon and Macassar)
Eucalyptus (Algeria)
Fullers Teazle (France and Germany)
Gru-gru (West Indies)
Guelder Rose (Balkans)
Hazel (Continent of Europe)
Lancewood (South America)
Loya cane (Australia)
Malacca (Siak)
Medlar (France)
Midgen (Australia)
Myall-wood (Australia)
Myrtle (Algeria)
Nana cane (Algeria)
Olive (Algeria)
Orange (Algeria)
Orange Black (Algeria)
Palmyra (India)
Partridge cane (China)
Partridge-wood (West Indies)
Penang Lawyer (Penang)
Pimento (West Indies)
Pomegranate (Algeria)
Rajah cane (Borneo)
Rattan (Eastern countries)
Snakewood (Persia and Brazil)
Tonquin cane (China)
Whangee (Japan)

Popular Woods. Acacias are much used for ladies' umbrellas and for sunshades. Beefwood is a dull, red colour. Two kinds of cherry-wood are now popular in the stick trade — the scented cherry and the tiger cherry. Carolina reeds are slender bamboo-like canes. The Spanish chestnut does not come from Spain, nor do Malacca canes come from Malacca. The latter are the product of a climbing palm found in Siak, on the opposite coast of Sumatra; they are the most expensive sticks on the market. Gru-gru sticks are saplings of a West Indian palm. Macassar ebony (flowered) makes very choice sticks, which are cut from the solid wood. Loya canes and midgen are both Australian palms. The wood of American birdseye maple is used as well as the branches of the British tree. Olive, partridge, pimento, rajah, snakewood, and whangee canes are all very popular. Snakewood of bright-red colour, with dark transverse blotches, makes one of the handsomest sticks possible when properly finished and mounted. Whangee canes are pliable, usually pale yellow in colour, but there is a variety with black scars which is known as black whangee. Walking-sticks should not be pulled or cut later in the spring than February, nor earlier in the autumn than October; the best time is early in December or in the middle of February. They should not be stripped of the bark, or "worked" until they are half dry; meantime, they should be stored in a cool and moderately dry place, and roots and spurs should be left on while drying. When half dried, they are ready for trimming, straightening, or bending, as required.

Preparing the Sticks. The process of straightening crooked sticks or bending straight ones, is accomplished by holding them over steam, or plunging them into hot, wet sand, until pliability is attained. They are then given the form desired while hot, and kept in that shape till cold. Straight sticks are usually tied firmly in bundles, and wound round with a coil of rope from end to end, or they are suspended from a beam by the knot-end, with a heavy weight hanging from the other end. Crooks are usually made by immersing in boiling water for from five to ten minutes, then bending into the requisite shape, and securing with a tourniquet until cold. There are varieties of handles; among them the crutch, the half-crutch, the whip, the C-hook, and the shepherd hook. Of these, the C-hook is the most popular at the moment for either umbrella or walking-stick. After bending, the bark is stripped, then the knots and knobs are trimmed, but considerable skill is required in trimming knobs. Sticks with the rough bark left on—such as elm—should be trimmed naked round the neck of the knob, and at the bottom, by the ferrule. The rough bark should be removed and the trimmed parts lightly gone over with glass-paper. The stick is then dressed with boiled linseed oil, and left to dry; the trimmed parts are afterwards polished, and finally given one or two coatings of hard spirit or copal varnish. Sticks are stained black after they have been glass-papered, and before they are dressed with oil, by first brushing them over with a hot and strong decoction of logwood and gall nuts, and when that is dry another brushing is applied of vinegar or acetic acid in which a quantity of protosulphate of iron, some iron rust, or even some rusty nails have been steeped for two or three days previously. Dragon's blood added to the varnish gives a brown or mahogany tint, and yellow ochre gives a yellow, while ink is sometimes used for black stain, or drop-black is mixed with the varnish.

The Experience for the Retailer. It will thus be seen that there is much to be learned before one knows the trade. It is not necessary for the seller of umbrellas and sticks to be an adept at all the branches of the practical part of the business; but if he can get a few years while young in a warehouse where all the details are carried out, so much the better. There is no regular apprenticeship to the trade, but it is absolutely essential that he should be taught all the details of the construction of an umbrella—the putting together of the parts—in order that he may know how to repair. This experience may be acquired in a good-going business with a repairing connection, and many successful umbrella dealers have had no other experience. A good all-round knowledge of the business enables a man with a shop of his own to cope with the opposition of the street-sellers, the drapers, the hatters, the hosiers, and the tobacconists, who of late years have made stick and umbrella-selling important side lines. The umbrellas sold in the streets are usually made with the covers taken from old umbrellas, which the makers of these cheap commodities buy up second-hand from the shops. The big drapery businesses cut the prices of umbrellas considerably, often running a cheap line of umbrellas as a draw, and getting a profit of about sixpence or ninepence on each. But if the umbrella dealer is

able to do his own manufacturing, he need fear no opposition from anyone, provided he has learned how and where to buy to the best advantage.

Capital and Start. In order to make a creditable start in a small shop in a middle-class neighbourhood, a capital of about £200 is required. The shop need not be large—the smaller the better at first—and the fittings should not cost more than about £25. All that is necessary in the way of fittings is a row or two of wooden fittings specially made to hold umbrellas and sticks upright, a circular umbrella-stand or two to place here and there about the shop, and some window fittings. If a second-hand glass wall-case can be purchased cheaply, well and good, and a few drawers are advisable for keeping the better class goods from becoming soiled. A counter may or may not be an advantage, but if a counter with drawers behind can be secured, so much the better. For the work-room behind the shop a rough bench, a vice, and a few tools may be obtained at a cost of a few pounds, and a machine for stitching the covers is necessary for the repairer, and particularly if manufacturing is contemplated. The best time to start is at the beginning of summer, for more umbrellas are sold in the summer than in winter, January and February being the slackest months.

The First Stock. With the sum named in the bank and good references, the beginner would go, or send, to one of the large umbrella warehouses in London, or other centre, and select an opening stock of manufactured goods. He would order at least six dozen of ladies' and six dozen of gentlemen's umbrellas ready-made, and the selection would have to be done very carefully. The exigencies of the neighbourhood in which the new business was started would have to be provided for as well as foresight could determine. If the vicinity were mainly a resort for ladies, then a greater quantity of ladies' goods, with a few parasols, perhaps, would be ordered and fewer gentlemen's umbrellas. If the shop happened to be situated in a business neighbourhood mainly occupied by men, then the reverse condition would apply. Then the kind of neighbourhood has to be considered; the smart umbrella for the smart set, the useful and unornamental variety for the ordinary middle-class business man, and the cheaper variety for the workman and his wife. There are many things to be taken into consideration in order to make a representative and appropriate show; but the judgment of the buyer must be the guide. In selecting the twelve dozen umbrellas, the shapes of the handles, the quality of the covers, and all such details, must be gauged to the best of the experienced man's ability. Assuming a normal class of customers of about an equal number of male and female residents the beginner would order one dozen gents' umbrellas and one dozen ladies' to sell at 3s. 6d. each (cost about 2s. each); like quantities to sell at 4s. 6d. each (cost about 2s. 9d.); at 6s. 6d. (about 4s. 6d.); at 8s. 6d. (about 6s.); at 10s. 6d. (about 7s. 6d.); and at 12s. 6d. (cost about 9s. each). This purchase would take about £40, but he would get a decent discount for cash, and he would next turn his attention to walking-sticks. Much care would have to be taken in the selection of this stock and three or four gross of sticks would be needed to make anything like a show. The retail profit on walking-sticks is small, a shilling stick often costing 9d. or 9½d. At least £50 would be expended on an ordinary stock of walking-sticks.

Making and Repairing Items. After visiting the umbrella and walking-stick merchants he would think about the repairing department. So he would proceed to the warehouses where they make a speciality of umbrella covers and he would buy the silk, and other mixtures, either in the piece, or in ready-made covers. Umbrella silk is made largely at Lyons and Crefeld, but much of it is so loaded in dyeing that it cuts at the folds. Textures of pure silk, or of silk and alpaca mixed, have better wear-resisting properties. There are many combinations of silk and other materials used for covers, and the range in prices of ready-made covers, for instance, is considerable. Then there are seven different grades in covers, 20, 21½, 22, 23, 25, 26 and 27½, according to the size of the umbrella. Thus, prices for a representative selection may range from 10d. to 8s. 3d. for the smallest size cover according as the material desired is taffeta, gloria, levantine, satin-de-Chene, dagmar, gingham, bord, twill, or glacé. In like manner for the coverings in the piece one may pay from 1s. to 5s. 6d. or more per yard, according to the quality. Therefore, not more than £20 would be spent on covers; £10 on umbrella sticks of different lengths and varieties, and £5 on ribs—Fox's are the best. Ferrules cost 6s. 6d. per gross; caps, 4s. 6d. per gross; runners, 12s. per gross; and notches, 6s. 6d. per gross. These are all, of course, in different sizes, and a selected assortment of each is required. Elastic bands cost from 5s. 6d. to 7s. 6d. per gross; rubber rings, 3s. 6d. to 5s. 6d. per gross; and tassels, from 10s. to 40s. per gross. Reels of cotton and needles for machining must not be overlooked. The parasol business is mainly in the hands of the draper, but covers for parasols may be obtained as required from wholesale houses.

Display and Reward. A clean, bright shop, with the stock tastefully arranged, and giving the appearance that there is plenty more, are sure attractions. Umbrella dealers are not so enterprising as they might be in window displays. A fashionably dressed lady (in wax) with a smart parasol and a number of other open parasols placed negligently around should make an attractive summer window, while a male figure with an open umbrella and imitation rain or snow falling upon it from the ceiling would draw the crowd. Price-tickets marked in plain figures affixed to the umbrellas and walking-sticks in the window are always desirable, while a few artistic show-cards with legends such as "Repairing by skilled workmen," "Walking-sticks of all descriptions," "Sunshades of all hues," "Prepare for a Rainy Day," induce the attention of the passer-by. Repairing is a profitable part of the business. The usual charge for re-covering is 2s. 6d. for a lady's umbrella, and 3s. 6d. for a gentleman's, while the little things like broken ribs, fastening on ferrules and so forth repay the skilled workman handsomely. The beginner would do all these odd jobs himself, of course, but he would require a female helper for the stitching on of covers and so forth. Experienced women can be had for from 15s. to 20s. per week, provided the young umbrella dealer has no wife or sister to help him. The profit on the total turnover must not average less than 30 per cent., and it must not be forgotten that umbrellas are not bought every day. The trade is a slow one, and the most careful attention should be paid to repairing and re-covering, and the manufacturing department should be attempted when possible.

Continued

continued from page 5385

ENGLISH CHINA & PARIAN WARE

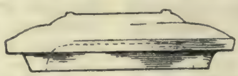
English or Bone China. Translucent Porcelain and its Preparation. Parian Ware. How Translucency is Attained. Pâte - sur - Pâte

By MARK SOLON

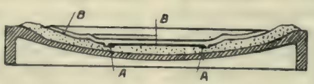
ENGLISH or bone china is the only form of translucent porcelain made to any important extent in England. Curiously, its manufacture is almost entirely confined to this country, where the bulk of it is sold. It has the advantage over Continental porcelain of being more easily decorated, from the fact that it is coated with a soft lead and alkaline glaze with which the enamel colours readily combine. It is also more durable than the Continental porcelain, not being so easily broken and chipped ; but, on the other hand, it is more liable to break with sudden changes of temperature.

Composition of China Body. The body is composed of calcic phosphate, introduced in the form of ground calcined bone, Cornish stone, and china clay in the following approximate proportions: Bone, 47 ; china clay, 23 ; and stone, 26. The translucency is to a great extent due to the Cornish stone, which at a high temperature melts and becomes a semi-transparent glass.

The *calcic phosphate* by its infusibility enables the ware to withstand the heat necessary for the vitrification of the Cornish stone without materially affecting the translucency.


29. PLASTER BEDDER

The preparation of the body is the same as already explained for earthenware. It has to be reduced to slip state, mixed, lawned, and passed through filter presses. On coming from the presses, however, the clay is beaten and kneaded by hand instead of being passed through the pug mill.



30. PLATE SUPPORTED ON FLINT BED

Owing to the absence of ball clay (which is excluded on account of the small percentage of iron which it invariably contains, and which would be detrimental to the whiteness of the ware), the body is not very plastic, and consequently difficult to manipulate.

Moulding Plates and Saucers. Flat ware, such as plates and saucers, instead of being formed mechanically by steel profiles, is moulded with small earthenware tools. The tool is held in the palm of the plate-maker's hand, and gently applied to the clay, which has previously been put on the mould [31]. The clay being of a dry nature does not readily respond to the form of the tool, and requires to be humoured into shape carefully and gradually.

The majority of hollow pieces such as cups, vases, etc., are cast in plaster moulds as explained under casting. The biscuit ovens are of same construction as already described, the heat being gauged by small china cups which are periodically drawn out and examined. The fire proceeds until the cups become translucent, and of a greyish-white tint. The presence of too much smoke or sulphur in the ovens causes the cup to turn pale green, while if the heat has been exceeded in any portion of the ovens, the surface of the cup becomes roughened with small blisters.

Supports in Biscuit Oven. During the latter stages of firing the ware passes into a semi-molten state, and must be well supported in order to retain its true shape. For this purpose every piece is placed separately on a bed of powdered flint. The bed, however, must be so formed that it not only provides sufficient support for the piece but also allows the clay to contract freely.

Plates and saucers are placed upon fireclay cradles or setters, which are prepared in the following manner:

A quantity of loose powdered flint is put upon the setter, and pressed into the correct shape with a plaster mould [29]. The small spaces AA [30] allow for the travel of the plate during contraction, while the flat beds BB provide a support for the rim and the centre.

Vases are supported in the same way in previously fired cylinders [32], the handle and neck being propped off the cylinder with small pieces of dry clay.

After *firing* and before *dipping* the biscuit ware is throughly brushed and sandpapered, a process called *scouring*. This is carried on over perforated benches under which which are closed ducts connected with an exhaust fan. The draught created by the fan prevents the operative from inhaling the flint dust, which is thus accumulated in the ducts.

Glazing Hollow Vessels. The glaze is applied by immersion as in earthenware. The biscuit, however, is *vitreous* and non-absorbent, and it is necessary to use the liquid glaze in a thick slip, sometimes thickening it artificially by adding a small quantity of a solution of alum or saltpetre.

In the *glost oven* the flat pieces are placed separately on fireclay cranks [33] inside saggers, the foot of the plate resting upon three sharp ridges, which are coated with a mixture of bone and stone, and so prevent the glazed piece from adhering to the crank.

The glaze is prepared in the same manner as the earthenware glaze, a frit being first made, which is afterwards ground with an admixture of lead, flint, stone, etc. The body being of different composition and of a very different density, it is necessary to introduce into it a larger quantity of carbonate of lead,

and decrease the proportion of Cornish stone, making a softer and more elastic glaze. The approximate proportions of these are as follow:

Frit—

Borax	26
Flint	22
Stone	28
Whiting	10
China clay	14
	100

To Mill—

Glaze frit	68
Carb. lead	20
Stone	5
Whiting	6
China clay	1
	100

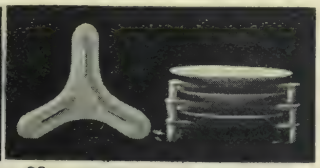
The glost oven is fired in exactly the same way as for earthenware.

Parian Ware. Parian is another form of translucent pottery which was produced in the first instance in biscuit state for the manufacture of statuary, and named from its similarity in appearance to Parian marble. When glazed it resembles china to a certain extent, but is of a much deeper cream tint. The body consists of felspar and china clay to which in some cases a small quantity of glass or frit is added to give an additional vitrescence and brilliancy to the biscuit.

31. CHINA PLATE MAKING

The felspar is generally calcined at a low heat before grinding; it becomes extremely friable after calcination, and is consequently more easily ground. The body, which is prepared in the manner already described, is mixed in the approximate proportions of felspar, 63; china clay, 36; and ball clay, 1.

32. METHOD OF SUPPORTING CLAY VASE DURING FIRING



33. FIRECLAY CRANKS FOR SUPPORTING PLATES IN THE GLOST OVEN

The Cause of the Translucency. The translucency is due to the fusing of the felspar, the body keeping its shape on account of the refractory nature of the china clay. The articles made from this body are almost invariably cast, the clay not being sufficiently plastic to manipulate in any other way. As the contraction of the body is very great, large pieces such as figures and large ornaments are supported during the biscuit fire after the manner already described for china. In some cases in which the biscuit finish is required the pieces are fired twice, a better and denser surface being obtained by burying the piece in fine sand for the second fire. The heat necessary to vitrify the body depends to a great extent upon the fusibility of the felspar employed; usually good potash felspar is used, containing about 15 per cent. of alkalies, in which case the ware is fired in the easier parts of an ordinary earthenware biscuit oven.

34. PLAQUE IN PÂTE-SUR-PÂTE

Pâte-sur-Pâte. The translucency of the body, and the brilliant colours which can be obtained by introducing metallic oxides into the clay, afford unique opportunities for clay decoration. One of the most important decorations of modern times in which advantage is taken of these qualities is known as "Pâte-sur-pâte" [**34**]. The ornament in white is, by a combination of painting and modelling, raised to various degrees of relief upon a coloured ground. The design is drawn in white slip directly on the dried clay piece. The dry clay readily absorbs the water from the slip, which is applied layer upon layer until the desired thickness is obtained. After biscuit firing the deep colour of the ground appears through the translucent white body to more or less pronounced degree according to the thickness of the ornament, the relief giving various effects from the thinnest film, which appears as a mere cloud upon the background, to an almost opaque white in the thicker modelled parts.

The Parian body is glazed with a rich lead glaze of the following approximate composition:

Frit—

Cornish stone	68
Flint	32
Whiting	8
Carb. lead	84

To Mill—

Frit	40
Flint	5
Stone	5
Carb. lead..	10

The glaze is applied, and fired in the manner already described under China, and the on-glaze decorations are to a great extent the same.

Continued

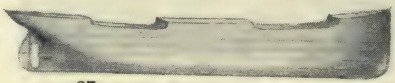
Group 29
TRANSIT
25
SHIPBUILDING
Continued from page 5402

THE SHIPYARD DRAWING OFFICE

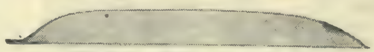
The Drawing of a Set of Lines. Preparation of the Model. Operation of Laying off. Working Drawings. The Ordering of Material

By Dr. J. BRUHN

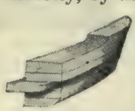
IN every shipyard there is a department called the drawing office, where all the plans according to which the ship is to be built are prepared. Drawings are necessary not only to guide the workmen in the construction of the vessel, but they are also required, among other things, for the ordering of material from the steel-rolling mills, which must be done some time prior to beginning operations in the shipyard. In the preparation of these plans it is necessary that the exact form of the vessel should be known. The most direct way of representing the form is by means of a model, which is a replica of the ship on a small scale. Such a model is usually made, in the first instance, in order that the owner may realise and approve the form proposed by the shipbuilder, but this particular one is, more or less, only for appearance and general guidance. A real working model is, however, essential for each ship. As the two sides of a ship are alike, it is necessary to make only a model of one half, or one side of the ship, as shown in **27**. It is usually made on a scale of a ¼ in. equal to 1 ft. Several deal boards, ½ in. in thickness, are fastened together to form a block of wood, and out of this the model-maker shapes the form of the ship in such a way that the planes of the deal boards are horizontal or parallel to the keel of the vessel. Figure **28** represents the forward part of a model, which is supposed to have been cut off from the remainder, to show the board construction. Instead of representing the form by means of a model, it is usually more convenient to do this by drawings, but the curved and unsymmetrical shape of the surface of a ship cannot be exactly represented on paper, like the plain rectangular surfaces of, say, a building on land.



27. HALF MODEL OF SHIP



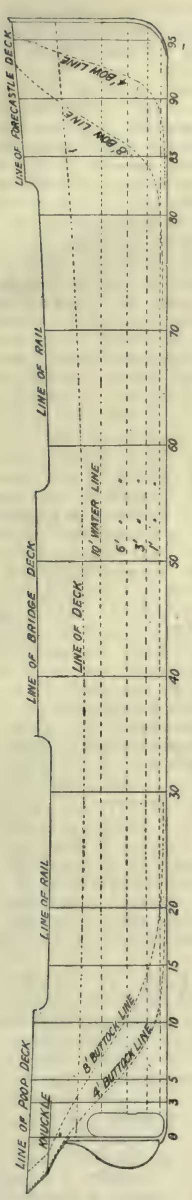
29. WATER-LINE SECTION



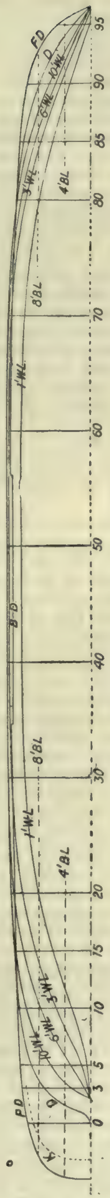
28. FORE PART OF MODEL

The Form of a Ship. The method adopted to indicate the form of a ship by means of a drawing is the usual one resorted to for irregularly shaped forms—that, namely, of showing the intersections of a series of parallel planes with the surface to be represented. Strictly speaking, any set of planes might be selected for this purpose, but it is convenient to choose one of the sets symmetrical with regard to the principal dimensions of the ship. The intersection between a horizontal plane and the surface of a ship is called a *water-line*, as it will indicate the form of a line at which the vessel might float, or might be imagined to float, in water It will be seen that the planes of the deal boards of which the models are made represent water-line planes. The thicknesses of the boards correspond to the distances between the water-lines. If the model be taken to pieces, we obtain a complete series of such water-line sections, and if one of them is taken and laid on paper, as indicated by **29**, it is an easy matter to draw a line round it, which will then represent that particular water-line. Other lines might be drawn in the same way, care being taken to see that they are in proper relative positions to each other. All the lines representing the intersections between the water-planes and the middle-line plane, or the vertical longitudinal plane dividing the ship into two halves, should coincide, as should also the line representing the intersections with a vertical transverse plane. A system of lines may thus be obtained which represents the exact form of the vessel at the particular horizontal planes, and if the space between the lines is sufficiently small, then the surface of the ship will, for practical purposes, be determined entirely by these lines.

Lines of a Ship. The method of obtaining the form of a ship by first carving it out in wood, and then transferring it to paper, is the most direct one, and is the ideal one to the experienced man who has a keen perception of form, and is able to produce readily the model of the ship that will satisfy all the required conditions. The usual method, however, is the reverse of this—namely, first to arrive at a paper representation of the form, and then transfer it to the solid by cutting the model in accordance with the drawing. On paper, the form of a ship is represented by a set of three views of the vessel, or, more correctly, by the intersection between certain sets of parallel planes and the surface of the ship. The three views are called the *body plan*, the *elevation*, and the *half-breadth plan*. Together they constitute what is called the *line drawing*, or simply the *lines* of the ship. If we imagine the surface of the ship intersected by parallel horizontal or water-line planes, then these intersections will appear as straight lines, if the ship is viewed endwise or sideways, but they will appear as curved lines if the vessel is looked down upon from above. In other words, the form of these intersections will be determined entirely by their projections on a common horizontal plane. Such a set of projected horizontal curves is shown in **31**. They constitute the water-lines, and the plan containing them is called the *half-breadth plan*, because it is always drawn for one side of the vessel only. These curves are clearly the same as those produced by laying the horizontal model sections on paper and drawing a line round them, as described above. Other curves besides those absolutely horizontal may be projected on a horizontal plane, such as the outlines of the various decks. The surface of the ship may also be imagined intersected by a set of vertical planes parallel to the middle-line plane. The intersections thus produced will appear as straight lines in the end and downward views of the vessel, but as curves in the side view. Their forms will therefore be fully represented by their projections on a vertical plane. The elevation drawing [**30**] shows such



30. ELEVATION DRAWING OF LINES

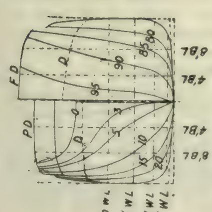


31. HALF-BREADTH PLAN

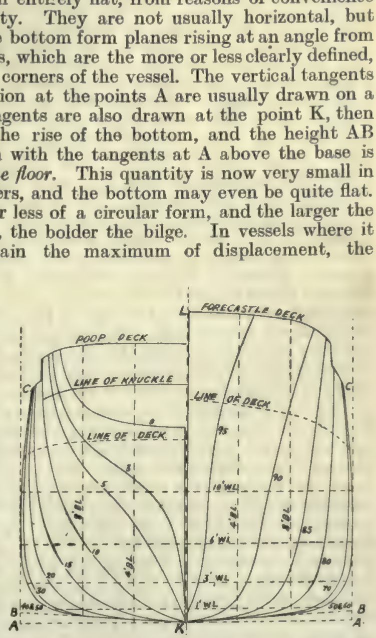
a set of projections, together with the projections of the deck-lines.

Cross Sections. Again, we may imagine the vessel's surface cut by a series of parallel vertical planes now at right angles to the middle-line plane. The intersections thus produced will be the cross sections of the vessel, and will appear as straight lines in the side and horizontal views, but as curves in the end-on view. They are, therefore, represented by their projections on a vertical plane at right angles to the middle-line plane. Figure **32** shows such a set of curves, and the plane containing them is called the *body plan* of the vessel. Besides the vertical cross sections, it also—like those of the other views—contains projections of the deck-lines. If it is simply a question of obtaining a representation, or of keeping a record of the form of the vessel, then the body plan is the most convenient for the purpose. The curves it contains are smaller and more easily drawn, and are produced by more clearly defined intersections than those of the half-breadth and elevation plans. Figure **32** shows the body plan on the same scale as the elevation and half-breadth plans, and **33** shows the same body plan on a larger scale. The cross-sections represent the form to which a frame has to be bent, and their numbers correspond to the numbers of the frame from the after end, No. 0 frame being at the sternpost of the vessel. The sections of the fore-body, or the forward half of the vessel, are usually arranged to the right of the middle line, and those of the after-body, or the after half of the vessel, to the left. The largest section is usually at or near amidships, and is therefore called the *midship* section. Very often a considerable part of the middle body of the vessel is of a prismatic form, so that several cross sections may be identical and appear as one in the body plan, as, for instance, those from No. 40 to No. 60 in **33**.

Form of Midship Section. The form of the midship section is very important, and its character becomes practically a key to the form of the ship. It is determined by the rise of the floor, the round of bilge, and the tumble-home of a vessel. The line KL in **33** represents the middle line of the vessel, and AA is the base line. Most ships have some parts of the bottom entirely flat, from reasons of convenience rather than necessity. They are not usually horizontal, but the two sides of the bottom form planes rising at an angle from the keel to the bilges, which are the more or less clearly defined, rounded, immersed corners of the vessel. The vertical tangents to the midship section at the points A are usually drawn on a body plan. If tangents are also drawn at the point K, then they will indicate the rise of the bottom, and the height AB of their intersection with the tangents at A above the base is called the *rise of the floor.* This quantity is now very small in all sea-going steamers, and the bottom may even be quite flat. The bilge is more or less of a circular form, and the larger the radius of curvature, the bolder the bilge. In vessels where it is desirable to obtain the maximum of displacement, the bilges are made very sharp, or nearly square. Above the water the side of a vessel usually falls in a little from the vertical tangent. The amount by which it does so is called the *tumble home,* and it may be measured either at the deck or at the rail height, as at C [**33**]. On the other hand, if a section is broader at the top than at the bottom, it is said to have *flare,* a term that is more particularly applied to the sections near the fore end of a ship. The water-lines are usually numbered according to their height in feet above the base line.



32. BODY PLAN



33. BODY PLAN ON LARGER SCALE THAN 32

Sometimes the sections shown in body plan are completed by drawing in the sections of the deck, or the lines of the beams, as well as those of the frames. A cross section of the deck is, however, of a comparatively simple nature. For drainage purposes, the deck is higher at the centre than at the side of the vessel. The usual elevation at the centre of the upper deck above the side is about ¼ in. to every foot of the breadth of the ship, and the beam is bent in the form of a very flat arc of a circle or a parabola, the ends of which are at the sides of the vessel, and the crown at the middle. These lines are not shown in **32** and **33**, as they would, owing to their closeness, make the representation very indistinct.

Elevation. Figure **30**, showing the elevation, gives the profile form of the stem and sternpost. In the case shown the line of the keel is horizontal or at right angles to the sections numbered 0 to 95. In some vessels, particularly in yachts, it may not be horizontal, but may rise towards the fore end of the vessel. It will be observed that the line of the deck is not horizontal, but rises both forward and aft. The lowest point is usually at, or a little abaft, amidships. The rise of the ends above this point is called the *sheer* of the deck-line. It is, as a rule, about twice as great forward as aft, and it is given to a vessel with a view to elevating the extremities, and thereby to keep them further out of reach of breaking seas. It tends also to give a graceful appearance to the structure. Seen in profile, the lines of the various decks and of the rail are more or less parallel. The intersections between the surfaces of the ship and the vertical planes parallel to the middle-line planes are called *bow-lines* in the fore-body, and *buttock-lines* in the after-body. They are numbered according to their distance in feet from the middle-line plane, and are shown in **30**. They are not, however, of much direct use, beyond indicating the characteristics of the form of the ship. The part of the after end of the structure, projecting over and thus protecting the rudder, sternpost and propeller, is called the *counter*. The form of the vessel shows, in most instances, an abrupt change here at a line designated the *knuckle*.

Water-lines. The half-breadth plan [**31**] simply shows the water-lines, already described, and the plan view of the deck-lines. The forward wedge-shaped part of the water-line is called the *entrance* of the ship, and the closing in at the after end the *run*. The deck-line shown in the elevation plan is the line of the deck at the side of the vessel. Sometimes the line of the deck at the centre of the ship is also shown. It is nearly parallel to the deck at the side, being at a distance above it equal to the round-up of the beam, explained previously. This line is, for the sake of clearness, not shown in **30**. Strictly speaking, either the body plan, half-breadth plan, or elevation, would be sufficient to determine completely the form of the vessel if a sufficient number of sections were used, as any two of them can be produced from the third. It will, for instance, be seen that the breadth of any water-line plane at each cross section can be obtained from the body plan; or, on the other hand, the breadth of a cross-section at the various water-lines can be obtained from the half-breadth plan. It is, however, more convenient to use the three representations, as fewer sections are then necessary to determine the shape with the same degree of accuracy. The exact shape represented by the lines of a ship is not usually the extreme outside surface of the vessel (which is more or less irregular, owing to the overlapping of the shell plates), but is an imaginary surface formed by the outside edges of the frames. If a point is desired on the real outside surface of the shell, the thickness of the plating has to be allowed for.

Drawing a Set of Lines. It is essential that the intending naval architect should become familiar with the methods of drawing the unsymmetrical curves which are characteristic for ship forms, and which appear more or less in all sketches for the building operations. These lines are drawn by means of battens or curves. A set of the former is kept in every ship-drawing office. They consist of smoothly-planed lancewood splines, varying in lengths from 15 in. to 60 in. They are of a rectangular section, but of varying thicknesses. Some are parallel, and some are tapered towards one or towards both ends. Any curve of an unsymmetrical character is usually determined by some points of it being given, and the curve is then drawn to pass through these. It will be clear that, strictly speaking, many curves might be drawn through any given number of points, as A, B, and C in **34**, When more points of the curve are given, then less variation is possible between the curves that can be drawn through them—that is, two curves of a very different character may be drawn through the points A, B, and C, as shown in **34**; but if it is known that the curve in question must also pass through the points D and E, then there is very much less scope for variation, and by choosing the points close enough, the curve may be defined with any required degree of accuracy. Comparatively few points, however, are needed to determine ships' curves with sufficient exactness, because their general character is known. They must always be what is called *fair*—that is, they can have no abrupt kinks. The curvature must change gradually from point to point. If a batten is bent, and made to pass through the points A, B, and C [**34**], but otherwise left free, its curvature will be of a gradual character such as is required in most ship curves, and the chances are that it will pass through, or near to, points D and E, which must also be on the required curve.

34. DRAWING CURVES

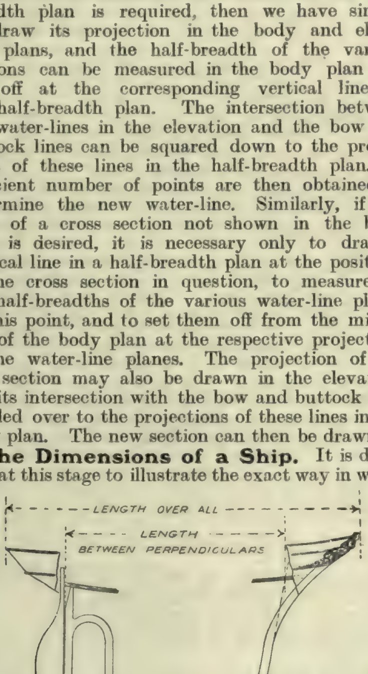
Approximation Method. If, however, it should not pass exactly through these points, it may, with a little force, be made to do so, and a line can then be drawn along it which will represent the required curve with a degree of accuracy which is usually sufficient for all practical purposes. Let it be required to draw one of the water-lines shown in **31**. The base line is then first laid down, the vertical lines representing the various sections are drawn, and the known half-breadths of the water-planes are set off from the centre line. A series of points on the required curve is then known. A batten is laid on the paper with its outside edge passing through the various points, where it is held by the pressure of lead weights of a suitable form, and a line can be drawn in. As little force as possible should be used in adjusting the batten to pass through the points; but, on the other hand, the spline must be of reasonable stiffness, because, if it is too thin, it will clearly not spring so "fair" as desirable between the fixed points. Where a curve is flat, as the water-lines [**31**] are near amidships, the batten can be thicker without requiring undue force to make it pass through the points.

Where the curvature is greater, as towards the ends of the water-lines, it must be thinner, or the pressure of the lead weights would not be sufficient to hold it in position. This is the reason why most of the battens are tapered towards at least one of the ends. This method of drawing ships' curves is particularly applicable where the curves are long, as in the case of those shown on the half-breadth and elevation plans.

Drawing "Curves." The other method of producing the curves when a number of its points are given, is by means of moulds, or "curves," a set of which is also kept in all ship-drawing offices. They are simply thin wood battens cut to the shapes of various curves which occur frequently in the drawings of ships. If properly selected, some 20 or 30 of these "curves" will suffice to draw all ordinary ship curves. When the points through which the required line must pass are determined, a mould is laid on the paper so that its outside edge passes through as many of the given points as possible, when part of the curve may be drawn; and by selecting suitable moulds, successive parts may be drawn until the curve is completed, the important point being to see that there is no discontinuity in the line at the junctions of the parts.

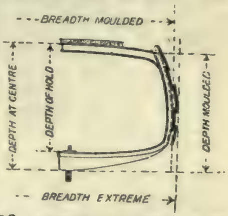
When the lines of a ship are at hand, the form of the vessel at any place can be easily determined. If a water-line not shown on the half-breadth plan is required, then we have simply to draw its projection in the body and elevation plans, and the half-breadth of the various sections can be measured in the body plan and set off at the corresponding vertical lines in the half-breadth plan. The intersection between the water-lines in the elevation and the bow and buttock lines can be squared down to the projections of these lines in the half-breadth plan. A sufficient number of points are then obtained to determine the new water-line. Similarly, if the form of a cross section not shown in the body plan is desired, it is necessary only to draw a vertical line in a half-breadth plan at the positions of the cross section in question, to measure off the half-breadths of the various water-line planes at this point, and to set them off from the middle line of the body plan at the respective projections of the water-line planes. The projection of the new section may also be drawn in the elevation, and its intersection with the bow and buttock lines levelled over to the projections of these lines in the body plan. The new section can then be drawn in.

The Dimensions of a Ship. It is desirable at this stage to illustrate the exact way in which

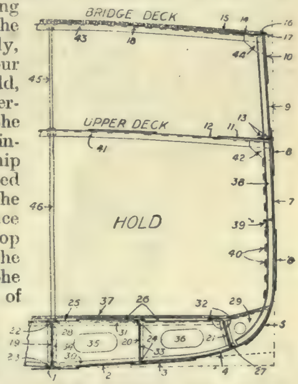


35. SKETCH SHOWING HOW LENGTH IS MEASURED

the various principal dimensions of the ship are measured. The length with which the shipbuilder and owner usually deal is the length between perpendiculars. It is measured on the uppermost continuous deck from the after side of the sternpost to the fore side of the stem. If the sternpost is inclined aft, or, as it is called, has a *rake*, then the after side of it is produced until it meets the deck-line of the centre of the ship [35]. The vertical through this point is called the *after perpendicular.* If the stem is bent to form a cut-water, as in most sailing ships and yachts and in some steamers, then the line representing the fore side of the stem below the water is continued in the same direction, until it meets the deck-line at centre, as shown by 35. The vertical line through this point is the *fore perpendicular.* Whenever it is not otherwise stated, the length mentioned is usually the distance between the fore and aft perpendiculars. For some purposes, the length over all is required. It is measured from the aftermost point of the counter to the foremost part of the stem, as also shown in 35. The breadth commonly used by shipbuilders is the moulded breadth of the ship measured at the outside edge of the frames, or at the broadest part of the midship section, as shown in 36. Owners, on the other hand, often use breadth extreme, which is equal to the moulded breadth plus the thickness of the shell-plating at the side of the vessel. Usually, there will be four thicknesses to add, owing to the overlapping of the plates. The ordinary depth of a ship is the moulded depth, which is the vertical distance between the top of the keel and the under side of the deck or the top of the beams amidships at the side of the vessel, as indicated in 36. Sometimes the depth at centre is used, and it is measured from the top of the keel to the underside of the deck or the top of the beams amidships at the centre line, as also shown in 36. Owners often use the depth of hold, which is measured from the top of the floors, or inner bottom, to the top of the beams of the uppermost deck. There are dimensions measured in various other ways, such as registered dimensions, tonnage dimensions, displacement dimensions, etc., but they will be explained in later articles as it becomes necessary to refer to them.



36. SKETCH SHOWING HOW BREADTH AND DEPTH ARE MEASURED

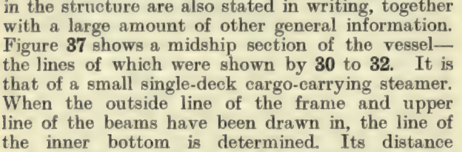


37. MIDSHIP SECTION

The Midship Sections. When the lines have been drawn, the various other plans necessary for the building of the ship can be begun. One of the most important of these is the one designated the *midship section.* In outline it is simply a copy of the midship cross section of the body plan, but it is usually drawn to double the scale. This section is so important at the beginning

of the ship that it is often prepared before the line drawing. If that is done, it means that the form of the midship section is decided upon before the form of the vessel in other respects has been arranged, and the lines of the ship must be completed so as to agree with the given midship section. Besides the outline of the frame section, the lines of the various decks are shown on the midship section drawing, as is also a cross section of all the material. In other words, the representation is that of a proper cross section of the vessel. No other single drawing gives so much information about the character of the proposed vessel as the midship section; but to add to this, the exact dimensions of all the important material in the structure are also stated in writing, together with a large amount of other general information. Figure **37** shows a midship section of the vessel—the lines of which were shown by **30** to **32**. It is that of a small single-deck cargo-carrying steamer. When the outside line of the frame and upper line of the beams have been drawn in, the line of the inner bottom is determined. Its distance from the outer bottom is usually given at the centre and at the side, and it depends upon considerations of strength and of the amount of water ballast to be provided for. In some cases it is horizontal, but it may slope either towards the side or towards the centre, according to the system of drainage adopted.

Frames. Next, the frames may be drawn. In the double bottom they are simply formed of a small angle attaching the outer plating to the vertical floor-plates. Outside the double bottom they are of various forms. They may be built up of the plain frame angle with another angle called the *reversed frame*, riveted at its inner edge, as shown in **38**. Instead of the frame and reversed frame, a solid rolled section may be adopted. The channel



SECTIONS OF FRAMES

section [**40**] is perhaps the most convenient. The Z section [**39**] is similar to the channel section, but has the flanges showing in opposite directions. The most popular frame section at the present time is the bulb angle section [**41**], which is an angle with a thick bulb at its inner edge in lieu of the reversed frame. This form of frame has been shown in **37**. Frames are, for reasons of convenience, always fitted in such a manner that the flanges which attach them to the shell plating are turned towards amidships. The section shown in **37** may, therefore, be supposed to be just forward of amidships and looked at from abaft. The frames have, therefore, their fore and aft flanges turned towards the viewer. As the frames are, in this particular instance, of the bulb angle section, reversed frames are shown only on the floor-plates in the double bottom, where they are on the side opposite to that of the flange. No reversed frame is shown on the small floor end bracket outside the double bottom, but the upper edge of the plate is bent at right angles to the remainder, so as to form a stiffening flange in place of an angle bar. The method of thus forming a flange on a plate is very often adopted in order to form an attachment, as, for instance, in a case of the floor-plates of double bottoms, where the flange may take the place of a frame or reversed frame.

Specification of Scantlings. The drawing of a midship section has been described. The importance of this document lies more in the written than in the drawn information it contains. The exact form of the outlines of a midship section is very important in itself, and must be definitely determined some time before work is begun, but an approximate outline is usually quite sufficient to form a basis for all the specified particulars of the structure which are recorded here. As already stated, the scantlings or dimension of all the various principal items in the structure are given on the midship section. The equipment, such as weight of anchors, size of chain cables, hawsers, etc., is also shown. The following is a specification of all the particulars which would have been indicated on the midship section shown in **37** of the previous article, but which have been left out there owing to the reduced scale of the illustration; the numbers in brackets refer to those shown in **37**:

Midship Section Scantlings. Frames [38] of bulb angles, $4\frac{1}{2}$ in. by 3 in. by $\frac{7}{20}$ in. for three-fifths the vessel's length amidships, to $\frac{6}{20}$ in. at the ends; spaced 22 in. apart, centre to centre.

Reversed frames. None.

Side stringer in hold [39]. Of bulb angle, 5 in. by 3 in. by $\frac{7}{20}$ in., with $\frac{6}{20}$ in. intercostal plate attached to outside plating by angles 3 in. by 3 in. by $\frac{6}{20}$ in.

Watertight bulkheads. Lower half of plating $\frac{6}{20}$ in.; upper half, $\frac{5}{20}$ in., stiffened by 4 in. by 3 in. by $\frac{7}{20}$ in. angles, spaced 30 in. apart, centre to centre, and bracketed to tank top and deck plating. Bulkhead frames, 3 in. by 3 in. by $\frac{6}{20}$ in., double angles. Angles attaching bulkheads to tank tops, 3 in. by 3 in. by $\frac{6}{20}$ in. double, and to deck plating 3 in. by 3 in. by $\frac{5}{20}$ in. double.

Pillars, in hold [46], 3 in. in diameter, of solid iron and fitted at alternate frames. Under bridge [45], $2\frac{1}{4}$ in. in diameter, of solid iron and fitted at alternate frames.

Beams. Upper deck beams [41] of plain angles, 5 in. by 3 in. by $\frac{6}{20}$ in., fitted at every frame with bracket knees [42] $12\frac{1}{2}$ in. by $12\frac{1}{2}$ in. by $\frac{7}{20}$ in. Where the length of beam at ends is less than three-quarters the midship length, the beams may be reduced by steps of $\frac{1}{2}$ in. to $3\frac{1}{2}$ in. by 3 in. by $\frac{6}{20}$ in. Beams at ends of hatchways, 7 in. by 3 in. by $\frac{9}{20}$ in.; bulb angles with knees, $17\frac{1}{2}$ in. by $17\frac{1}{2}$ in. by $\frac{9}{20}$ in.

Bridge deck beams [43], $4\frac{1}{2}$ in. by 3 in. by $\frac{7}{20}$ in.; plain angles at alternate frames with knees, $11\frac{1}{4}$ in. by $11\frac{1}{4}$ in. by $\frac{7}{20}$ in.

Poop beams, 4 in. by 3 in. by $\frac{7}{20}$ in., plain angles at alternate frames with knees 10 in. by 10 in. by $\frac{7}{20}$ in.

Forecastle beams, 5 in. by 3 in. by $\frac{7}{20}$ in., plain angles at alternate frames with knees $12\frac{1}{2}$ in. by $12\frac{1}{2}$ in. by $\frac{7}{20}$ in.

Forgings. Stem, $6\frac{1}{2}$ in. by $1\frac{7}{8}$ in. at bottom, tapering to $5\frac{1}{2}$ in. by $1\frac{1}{2}$ in. at head.

Propeller post, $6\frac{1}{2}$ in. by 4 in.

Rudder post, $6\frac{1}{2}$ in. by $3\frac{3}{4}$ in.; sole piece, 7 in. by 4 in.

Rudder stock, 5 in. in diameter.

Pintles, $2\frac{1}{2}$ in. in diameter.

Single plate, $\frac{14}{20}$ in. in thickness.

Plating. Keel plate [1], 32 in. by $\frac{12}{20}$ in. for three-quarters the vessel's length amidships to $\frac{11}{20}$ in. at ends.

Garboard strake [2], $\frac{9}{20}$ in for half the vessel's length amidships to $\frac{8}{20}$ in. at ends.

Bottom plating [3], $\frac{8}{20}$ in. for half the vessel's length amidships to $\frac{6}{20}$ in. at ends.

Bilge plating [4 and 5], $\frac{7}{20}$ and $\frac{8}{20}$ in. for half the vessel's length amidships to $\frac{6}{20}$ in. at the ends.

Side plating [6 and 7], $\frac{7}{20}$ and $\frac{8}{20}$ in. for half the vessel's length amidships to $\frac{6}{20}$ in. at the ends.

Sheerstrake [8], 33 in. by $\frac{10}{20}$ in. for half the vessel's length amidships to $\frac{7}{20}$ in. at ends. Doubled for 14 ft. at the ends of the bridge.

Poop, bridge, and forecastle side plating, $\frac{5}{20}$ in.

Upper deck stringer plates [11], 38 in. by $\frac{8}{20}$ in. for half length amidships to 20 in. by $\frac{6}{20}$ in. at ends. Stringer angles [13], 3 in. by 3 in. by $\frac{7}{20}$ in. to $\frac{6}{20}$ in. Deck plating [12], $\frac{6}{20}$ in. fore and aft; one strake at sides of hatchways $\frac{8}{20}$ in.

Poop, bridge, and forecastle deck stringer plates, 20 in. by $\frac{5}{20}$ in.; angles, 3 in. by 3 in. by $\frac{5}{20}$ in.; tie plates, 6 in. by $\frac{5}{20}$ in.; poop and bridge wood decks, $2\frac{1}{2}$ in. pine; forecastle wood deck, 3 in. pine.

Double bottom. Centre girder [19], 32 in. by $\frac{9}{20}$ in. to $\frac{8}{20}$ in.

Side girder [20], $\frac{6}{20}$ in.

Margin plate [21], 20 in. by $\frac{6}{20}$ in.

Floor plates [28], $\frac{6}{20}$ in.

Middle line strake of inner bottom plating [25], 32 in. by $\frac{7}{20}$ in. to $\frac{6}{20}$ in.

Inner bottom plating [26], $\frac{6}{20}$ in.

Keel angles [23], $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by $\frac{7}{20}$ in.

Centre girder angles [22], 3 in. by 3 in. by $\frac{7}{20}$ in. to $\frac{6}{20}$ in.

Margin angle [27], $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by $\frac{7}{20}$ in.

Frames in double bottom [30], 3 in. by 3 in. by $\frac{6}{20}$ in.

Reversed frames in double bottom [31], 3 in. by 3 in. by $\frac{6}{20}$ in.

All vertical and intercostal attachment angles in double bottoms, 3 in. by 3 in. by $\frac{6}{20}$ in.

Floor end brackets [29], $\frac{7}{20}$ in. in thickness, flanged on the upper edge and attached by single angles [32] to the margin plate.

Ceiling in hold [37], $2\frac{1}{2}$ in. pine.

Cargo battens [40], 6 in. by 2 in., spaced as shown.

Riveting. Butts of keel plate overlapped and treble riveted for entire length of vessel. Butts of garboard strake, bottom, bilge, and side plating overlapped and double riveted for half the vessel's length amidships, single riveted at the ends.

Butts of sheer strake overlapped and treble riveted for half the vessel's length amidships, double riveted at ends.

Butts of poop, bridge, and forecastle side plating, single riveted.

Edges of outside plating overlapped and single riveted.

Butts of upper deck stringer plates overlapped and double riveted for half the vessel's length amidships, single riveted at ends.

Butts of upper deck plating and of poop, bridge, and forecastle decks, stringer plates overlapped and single riveted.

Butts and edges of inner bottom plating overlapped and single riveted.

Butts of centre girder and margin plate overlapped and double riveted.

Rivets in butts of outside plating and deck stringer plates spaced three and a half diameters apart, centre to centre.

Rivets in edges of outside plating and deck plating, and in butts and edges of inner bottom and bulkhead plating, spaced not more than four and a half diameters apart, centre to centre.

Equipment. 1 bower anchor, each 10 cwt., $9\frac{1}{2}$ cwt., 9 cwt. 1 stream anchor, 4 cwt., and 1 kedge anchor, 2 cwt.

Chain cables, 195 fms., 1 $\frac{2}{16}$ in. stud link.

Stream chain, 60 fms., $\frac{12}{16}$ in. stud link.

Towline, 75 fms., $2\frac{3}{4}$ in. steel-wire rope.

Hawser, 90 fms., 6 in. hemp.

In some instances the specification of scantlings given on the midship section is much more detailed than in the example shown above. The exact width of all butt and edge laps and straps may be given, as well as the size and spacing of the rivets; the number and size of rivets in beam knee brackets, floor end brackets, and at head and heel of pillars, etc., may also be given. Usually, several midship sections are required for various purposes, and the information supplied will then vary in each case, according to the object of the particular section. One midship section will thus usually be required by the owner where certain general information is supplied: another more detailed one may be required by the institutions classifying ships for the purpose of insurance; and one with every detail shown on it will be necessary for the guidance of the workmen in the yard.

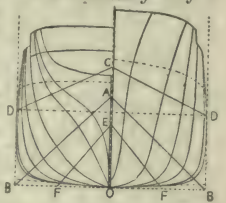
Fairing a Set of Lines. With the midship section and the line plan prepared, the general form of the vessel and its method of construction have been arranged. There remains, however, a considerable amount of draughtsman's work to be done before the actual building operations can be proceeded with. The lines, as supplied by the designer, are to a small scale—usually $\frac{1}{8}$ in. or $\frac{1}{4}$ in. equal to 1 ft.—and even if they are most carefully drawn they cannot be relied upon to be exactly correct when magnified so as to be applicable to the full size of the ship. It is the cross sections of the body plan that are directly used in the production of the form of the vessel. As stated in the article dealing with the lines, they represent the curves to which the frames must be bent; only a few cross sections are shown in an ordinary body plan, and as every frame must have its form given, it becomes necessary, for this reason also, to modify the designed body plan. To make the lines applicable to the full-sized form they must undergo an operation called "fairing," which practically consists in their being drawn to a very much enlarged scale, whereby possible irregularities will become apparent, and can be removed. In the time of wood shipbuilding this fairing of the lines, together with the determination of the form of the various frame-timbers, etc., was a very elaborate process, which went under the name of the "laying-off" of the lines. It was done by special men, and required a considerable knowledge of descriptive geometry. In passing from wood to iron and steel as the building material, the method of construction, and consequently also the production, changed somewhat, and the "laying-off" of a vessel became reduced to a much simpler process.

Full-size Laying-off. In many shipyards the lines are still laid-off and faired at full size, and a description is therefore made here of this operation. In the first instance, a copy of the designed lines, or a table of offsets, is supplied by the drawing office. The offsets are simply dimensions measured by the draughtsman on the drawing and recorded in tabular form. A set of vertical columns may be arranged for to correspond to the number of cross sections and similar horizontal columns to correspond to the water-lines. The half-breadths are measured at each water-line and each cross section, and noted down in the proper columns of the table. From these dimensions it is possible to reproduce the water-lines and cross sections. The offsets of other lines, as the deck, bow, and buttock lines, etc., are also noted. The

tables are handed to the man who has charge of the moulding loft—a place with a large, unobstructed floor, on which the lines are reproduced in chalk to full size. The depth and half-breadth of the ship usually fall within the limits of the loft, but the length of a large ship cannot be laid down in full, as that would necessitate an enormously long building. The cross sections or the body plan can therefore, be laid down to the absolutely correct full size, but the water and deck lines have to be what is called *contracted*. This simply means that the cross sections of the half-breadth plan and the elevation are spaced closer than in reality—say, one-fourth of the actual distance they are apart in a ship. This not only has the advantage of bringing the lines of the half-breadth plan and elevation within the size of a loft, but the increased curvature of the lines in these views enables their character to be more easily discerned by the appearance on the loft. Any unfairness—that is, a hump or cavity —that might exist in the designed lines, will be magnified on the loft 50 to 100 times, and can therefore be easily seen and removed.

Body Plan. The half-breadths having been set off at the water-lines of the body plan, the cross sections may be drawn in by means of long battens, made to pass through the required points, and held temporarily in position by spikes driven into the thick deal flooring. If, as will be usually the case, the battens will not pass easily through all the given points, then there has been an unevenness or unfairness in the original line, and the batten is now made to spring easily through the majority of the given points, and the line drawn in. The offset of the points that do not fall on the line are then corrected accordingly. When, in this way, the sections of the body plan have been drawn in and faired, then their actual half-breadths are transferred to a set of contracted water-lines. It might here happen that the cross section might be absolutely fair in a body plan, but all its half-breadths might be too large or too small. If a cross section is, in this way, either too broad or too narrow in relation to its neighbouring sections, it will at once be apparent in the contracted water-line plan, and can be corrected. When the water-lines have thus been faired, it is necessary to go back to the cross sections of the body plan and make them agree, where necessary, with the altered half-breadths. In the same way, contracted bow and buttock lines are drawn and made to correspond to both the amended water-lines and cross sections, and absolute agreement may thus finally be arrived at between all the views.

Diagonal Sections. The best sections for the purpose of arriving at a fair surface of the ship, with agreement between the various sets of projected lines, are those that cut the surface of the ship as nearly as possible at a right angle. The intersections of the various lines become thereby more clearly defined. For this reason special sections are often selected, and drawn only for the fairing process. The most convenient sections for this purpose are those made by the fore and aft planes at an angle to the middle-line plane. They are called *diagonal planes*, as they appear in the body plan as straight lines drawn diagonally from some point on the middle line to the surface of the ship, as AB, CD, and EF [**42**]. These lines will appear curved in both the elevation and half-breadth plans, but their real form is obtained by assuming the diagonal plan hinged about its intersection with the middle-line plane until it becomes parallel to the water-lines. Its horizontal projection will then represent its true form. This is easily obtained by dealing with the diagonal plan in question—say, AB [**42**], as if it were a water-line plane. It is necessary only to set off in the water-line plane, at their respective cross sections, the distances from A to the intersections of the diagonal plane with the sections of the body plan, as if these distances were half-breadths of a water-line. It is, of course, essential that these diagonal lines should be fair, and if they are so, there is a considerable guarantee that all water-lines and bow and buttock lines will also be fair; in fact, a few diagonal lines are, for fairing purposes, equivalent to a larger number of water-lines in conjunction with bow and buttock lines.

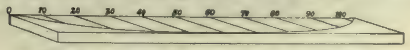


42. BODY PLAN WITH DIAGONAL LINES

Modern System of Laying-off Lines. The above-described method of laying-off a set of lines to full size on the loft is necessary in wood shipbuilding. When iron and steel are the building materials it is not essential that the laying-off process should be carried out at full size. In many respects, a smaller scale is here more convenient, and is adopted in many shipyards. The entire operation of fairing and laying-off the lines is carried out on paper by simply enlarging the scale of the designed lines—say, from ¼ in. equal to 1 ft., to ½ in., ¾ in. or 1 in. equal to 1 ft. The smoother surface of the paper, and the finer instruments used in producing the lines, enable a trained draughtsman to work with a very high degree of accuracy. In being able to discriminate between good and bad lines, it is, of course, practice that makes the master; the experienced eye will, by merely looking along a line in a fore-shortened view, discern a very small irregularity which the less-trained operator might hardly be able to measure by direct means When the exact desired fair form of the vessel has been obtained, by whichever method it is arrived at, a corrected table of offsets is made out, much more detailed than the original one produced from the designed lines. The offsets are usually given for water-line planes 2 ft. apart, or near the flat of the bottom, for every 1 ft., and for cross sections, 12 ft. to 16 ft. apart amidships; and 4 ft. to 12 ft. apart at the ends of the vessel. The offsets are also given for the deck lines—that is, their half-breadths and their sheer heights at the respective cross sections. The sheer heights are measured in the elevation from a horizontal line through the lowest point of the deck line or through the point where a vertical cross section amidships intersects this line. The offsets for the curve of the stem are also recorded. The vertical ones are measured from the base line at the top of the keel at the respective cross sections, and the horizontal ones from a suitable vertical line —say, one of those representing the forward cross sections and at the selected water-lines.

The Working Model. While the lines have been laid-off by the loftsman or a draughtsman, a working model may have been prepared by the model-maker from the designed lines. The method of obtaining a set of lines from the model was described at the beginning of this article. The making of a model from a set of given lines is equally simple. The model-maker supplies the draughtsman with a set of carefully-planed deal boards, the thickness

of which corresponds to the actual distance between the water-lines shown on the drawing. The draughtsman then simply transfers a water-line to each board, as shown in **43**, the centre line, and the lines representing the various cross sections, being first drawn. On the side of a rectangular piece of wood —somewhat thicker than the boards, but of the

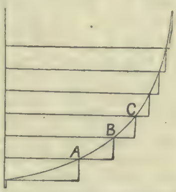


43. WATER-LINE SECTION OF MODEL

same length and breadth—a line is drawn, representing the deck at side, and also a profile view of the stem and stern or counter of the vessel, as shown in **44**. The various pieces of wood are then returned to the model-maker, who first of all cuts the boards to the required water-lines, and the top piece to the required deck-line. The uppermost piece is

44. TOP SECTION OF MODEL

then returned to the draughtsman, who now draws a plan of the deck-line on the top of the slightly curved surface, just as the water-lines were drawn on the plane surfaces of the boards. All the pieces are then glued together in their proper relative positions, so that the centre lines and the lines representing the various cross sections are directly over each other, or in the same vertical planes. When that has been done a rough model of the vessel has been produced, and it remains for the model-maker to trim down the ridges of the prismatic sections of the water-line boards until a perfectly fair and smooth surface is arrived at. In doing this he must, of course, take care to cut away only the superfluous wood outside fair sections, such as the one indicated by the line ABC [**45**].



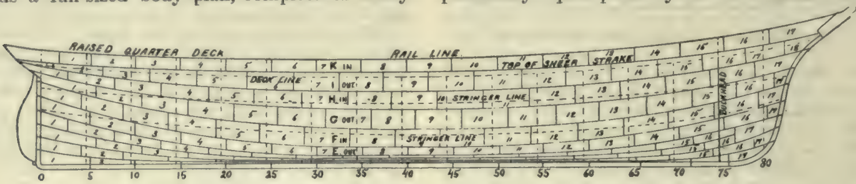
45. CROSS SECTION OF MODEL

Drawing on Model. The model is then slightly varnished in order that it may be drawn upon, and is returned to the draughtsman, who now has to prepare, on its surface, a complete representation of the framing, stringers, and outside plating of the ship. In doing this, he first of all marks the positions of each frame in the ship at the keel and numbers them from aft to forward. He then draws a line at these points, usually in red, representing the line of the heel of the frame angle from keel to gunwale. A special mechanism is used for this purpose, which enables a drawing pen to be guided in a plane that can be adjusted so as to be at right angles to the keel line of the ship. When all the frames have been drawn, the positions of the deck lines and stringers are determined. The upper edge of the model represents the upper edge of the sheer strake or the top of the rail bar. The distances of the deck lines and stringers below this line are measured on the midship section and the line plan along the edge of the respective frames, and are set off on the model from its upper edge, to which the line of the deck and stringers will usually be nearly parallel. These lines are drawn by means of flexible battens held in position on the model by fine pins. The lines of intercostal keelsons, and the margin plate of double bottoms, are also drawn similarly to those of the stringers, but their position is determined in relation to the keel line, their distances out on the frame lines being also measured on the midship section and on the line plan.

Outside Plating. The model is then ready to have the lines of the outside plating drawn upon it. The widths of the strakes of shell plating are arranged on the midship section, and they can, therefore, be transferred right away to the midship frame of the model. The upper edge of the sheer strake is usually at a certain height above the deck at side amidships, and, as a rule, it retains this height to the ends of the vessel. The line representing this edge may, therefore, be drawn parallel to the line of the deck in the manner in which the stringer lines were drawn. The lengths of the frame, or the half girth of the vessel from keel to gunwale, will vary through the length of the ship. From amidships, it will increase somewhat as the ends are approached, and the width of the total amount of shell plating must, consequently, also increase. The girth will attain a maximum, roughly speaking, at about one-fourth the vessel's length forward and aft of amidships. From these points it will be reduced towards the ends, where the total width of shell plating is, therefore, also reduced. The necessary increase and diminution in the amount of shell plating might be effected by increasing or diminishing all the strakes uniformly. It is, however, usual to have the strakes of the side plating practically parallel, fore and aft, and to let the necessary increase and reduction in width be confined to a few strakes in the bottom. In most cases, the half girth amidships is so much in excess of that at the ends of the vessel that it is convenient to let one of the strakes terminate before reaching the ends. Such a strake is called a *stealer*. In some instances there may be two, or even three, stealers.

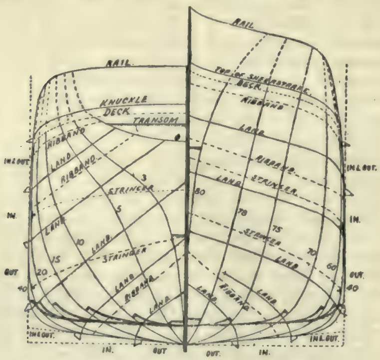
Edges of Plating. The edges of the side plating, including the lower edge of the sheer strake, are drawn parallel to the upper edge of the sheer strake at the proper distance below it. At the after end where the form fines away under the counter, the small flat battens, by which the lines are drawn, are allowed to spring freely—that is, they are not bent laterally, but merely twisted round the form of the vessel. In arranging the bottom plating, the same principle is adhered to of allowing the guiding battens as much freedom as possible, consistent with being held flat, by means of pins, to the surface of the model. This conduces to simplicity, as the individual plates of the strakes will then have a minimum of curvature in their edges and be more easily prepared. Care is taken in arranging the edges, or *landings*, as they are called, so that they do not run obliquely across the lines of an intercostal stringer, keelson, or margin plate of a double bottom, as complication would, in that case, arise with regard to the riveting. Figure **46** shows a profile view of a working model of a small sailing vessel. For simplicity's sake, only a very few of the frame lines are shown and only the outside edges of the plating are indicated. The fore and aft dotted lines represent the deck line and the side stringers. When all the widths of the plates have been arranged, the butts are drawn on the model. When the butts are strapped, they are arranged to be midway between the two frames, and the line of the butt is parallel to the frame lines. If, on the other hand, the butts are lapped, then they are usually close to one of the adjoining frames.

The Scrieve Board. When the working model of the vessel has been completed, the lines laid off and faired, and the correct offsets recorded, then the scrieve board is prepared. It consists of a large unobstructed black-painted floor like the moulding loft, but it is always of thicker planks at the ground level and adjoining the place in the yard where the frames are being bent. On these boards a full-sized body plan, complete in every small distance on the body plan between those sections, which can be scrieved to the offsets. In this space all the intermediate frame sections must fall, and the operator then simply divides it up into a number of smaller spaces corresponding to the number of frame sections required. The distance at a water-line between two drawn frames, as AB [49], will, if the space is small, be divided into practically equal parts by the intermediate frame



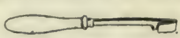
46. PROFILE VIEW OF WORKING MODEL OF SMALL SAILING SHIP

detail, is laid down for the guidance of the workmen bending the frames. Figure 47 shows a scrieve board body plan for a small vessel, with many of the lines omitted owing to the reduced size of the illustration. In the first instance, a base line and centre line are laid down. The vertical tangents to the midship section are drawn next as well as the rise of floor line. The water-lines are then drawn in chalk, parallel to the base line, and at their proper height above the top of the keel. The corrected half-breadths tabulated on the loft are set off from a centre line, one cross section being taken at a time.



47. SCRIEVE BOARD BODY PLAN FOR A SMALL VESSEL

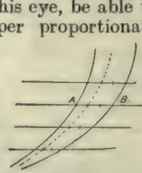
A batten of suitable stiffness is then bent, so that its outer edge passes through the various points. It is held in position as on the loft by means of long spikes driven into the boards, one on each side of the batten. When the operator judges that such a line of a frame is absolutely correct, then it is *scrieved*—that is, a permanent line is produced by means of a *scrieve knife* [48], which is a tool whereby a narrow groove can be produced in the boards. In this way all the sections for which offsets were obtained on a loft may be scrieved. If every frame section is not recorded in this way, it is necessary to scrieve the remainder of the frames by interpolation.



48. SCRIEVE KNIFE

Interpolation. For the ends of the vessel, every frame may have its offset tabulated. Nearer amidships, there will be only a comparatively

sections. They will not be absolutely equal, but the skilled draughtsman will, by his eye, be able to divide the space into the proper proportionate parts, say three, as shown in 49. Through the points thus obtained, the intermediate frame sections may be scrieved by the aid of battens, care being taken to see that the character of the lines is in accordance with the adjoining correct sections obtained from offsets. In laying down the recorded sections on a scrieve board, not only the water-line half-breadths are set off, but the bow and buttock lines are also drawn in parallel to the centre lines, and the heights of the intersections of these lines, with the various cross sections as recorded on the loft, are set up from the base line. These points are, in the flat of the bottom of a vessel, much more important than the half-breadths at the water-lines, as the bow and buttock planes at this place intersect the surface of the ship practically at right angles, whereas the water-line planes intersect it very obliquely. In addition to points obtained from the recorded half-breadths and heights of bow and buttock lines, others may be obtained by diagonal lines being laid down on the scrieve board, and their recorded distances set off from the middle line. It is, of course, of the highest importance that the form of the frame sections should be correct and all the various systems of points, through which they must pass, will mutually form a check on each other's accuracy.



49. FRAME LINES ON SCRIEVE BOARD

Stringers. The half-breadths of the uppermost deck line are also set off at the proper height above the base line, and they form the upper ending of the frame line. At the lower end, the frame sections terminate at the keel, and at the half-breadth of the stem and sternpost. When all the frame sections have been scrieved, the positions of the deck lines and stringers are marked. Their height amidships above the base line is obtained from the midship section. The heights towards the ends of the vessel are, in the case of the uppermost deck, determined by the recorded sheer heights, which can be set off at the proper frame sections. The line of the upper deck may therefore be scrieved through the points thus obtained. Other decks, such as poop, bridges and forecastle, middle and lower decks, are usually parallel to the upper deck, and their lines can be set off at the proper distance above or below the upper deck line. If these decks should not be parallel to the upper deck, their

height above the base line, or in relation to the upper deck, may be obtained from the line drawing, or from the offsets from the loft, and set off on the scrieve board. The lines of hold side stringers, side keelsons, and margin plates of double bottoms, are scrieved in a similar way to the deck lines, but in the case of keelson and margin plate lines it is the half-breadths instead of the heights that are used in determining the points on the cross sections.

Floors. The line of the frames is also the line of the outer edge of the floor plates. It is, however, also necessary to show the inner edge of the floor-plates in order completely to determine their form. The midship depths of the floor-plates at the middle line is usually retained well towards the ends of the vessel. At the side of the vessel the floor-plates usually rise above the height at the centre, and the point at which they terminate on the frame section is arranged on the midship section and on the line drawing. The floor ends are usually carried to a greater height amidships than towards the ends of the vessel, as shown by **47**. Right at the ends, where the vessel is of a narrow V form, the floor-plates are increased very much in depth, in order more efficiently to tie the frames of the two sides of the vessel together. The line of the height of floor ends at the frame sections will therefore rise very steeply at the extreme ends of the vessel. The upper edge of the deep end floors is straight, and may be drawn horizontally across on the scrieve board. The entire form of these floor-plates is therefore given. The midship floor-plates are not usually straight in a single-bottomed vessel, and it is necessary to draw the correct line of the inside edge of the floor-plates on the scrieve board. The depth of the floor-plate at the middle line is, as stated, nearly constant for the greater part of the vessel's length. The depth of the floor-plate nearer the side of the vessel is arranged on a midship section and on the line plan or directly on the scrieve board, where the depth decided upon at each section is set off inside the frame line. The inside edge of each floor may thus be scrieved when the complete form of these plates is obtained both amidships and towards the ends of the vessel. Where they terminate at the side, their breadths correspond to that of the frames. The line of the upper or inner edge of the floor-plate is, of course, also the line to which the inner edge of the reversed frames has to be bent.

Ribbands. In erecting the frames of a vessel, and before the plating, stringers and keelsons, are fitted, it is necessary to have certain temporary wood stringers, which hold the frames in their proper relative positions. These wooden stringers are called *ribbands*, and consist of planks 6 to 8 in. square, some of which are tapered towards the ends. They are bolted to the outside of the frames as the latter are being erected. The position of these ribbands on the frames has been arranged on the line plan or moulding loft, and must also be shown on the scrieve board, where they usually appear as more or less straight diagonal lines. Their position is fixed by the girth measurement on the frame section or by the half-breadths or heights above the base line. Accuracy is not so very essential in these lines, which serve only a temporary purpose in the act of construction. The widths of the outside plates are next arranged. They are measured off on the midship section and on the model at the various frame sections, and are then transferred to the scrieve board, where they are set off at the proper cross sections.

Landings. The lines of the edges or landings must, however, undergo a fairing process before they are finally scrieved. These lines will also appear in the body plan as practically diagonal lines, as shown in **47**. Two lines may be drawn for each edge of the overlap of the plates, and the space between them may be painted white, to distinguish these lines clearly from the ribband and stringer lines. Usually, however, only one of the lines of the laps is shown—namely, the line representing the edges of the outside strakes of plating. For practical reasons, the ribbands are arranged to be fitted in way of an outside strake, as they can then remain in position until the inside strakes are fitted, and are capable of keeping the frames in their proper place while the outside strakes of plating are being fitted. It will therefore be observed from **47** that the ribband lines are between the lines of the landing edges, and they are also kept clear, as far as practicable, of decks and stringer lines.

The Ordering of Material. When the faired line plan, the model, and the scrieve board are completed, the ordering of the material may begin. The angles for the frames and reversed frames may be ordered from the body plan, the model, or the scrieve board. The lengths of a number of frames are measured and plotted down on a drawing as ordinates, the spacing of which corresponds to the spacing of the frames measured. A curve is then drawn fair through the heads of the ordinates, and lines representing other intermediate frames are drawn in, and the lengths of all these can then be measured more conveniently than by measuring them individually on the loft or the scrieve board. Where there is only a single bottom, the length of the frame is measured from the keel to the gunwale. Where a double bottom is fitted, it is measured from the margin plate to the gunwale. A slight excess in length is allowed as a margin for possible errors, but for the midship portion of the vessel this should be only very small. At the ends, where there is more curvature in the frames, a larger margin is necessary. The lengths of the reversed frames are obtained in a similar manner to those of the frames. Whenever there is any doubt, the frames and reversed frames are measured on a scrieve board, but usually the line plan is sufficiently accurate for this purpose. The dimensions of the floor-plates may be obtained from the line plan or the scrieve board They cannot, however, be ordered to exact sizes, but must be obtained to simple rough shapes, usually with two parallel edges and tapered towards one or both ends.

50. SHEARED FLOOR-PLATE

These roughly-shaped plates must, of course, be large enough to enable the workman to obtain the exact size of the particular floor by shearing off the superfluous material. On the other hand, the size of the plates ought, for reasons of economy, to be such that a minimum of scrap or waste material is the result.

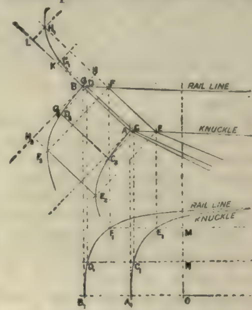
Floor-plates. If the floor-plate, shown by **50**, is to be entirely sheared out of the ordinary plate, then the latter must be of the shape A B C D. Sometimes, in single-bottomed vessels, the outer narrow end of floor-plates is bent to shape, in which case a considerable amount of scrap material may be avoided, as in ordering the plate it is necessary only to suppose the outer end turned down in line with the remainder of the floor-plate. A B C D [**51**] will then provide sufficient material of the floor-plate. In some instances, the floor-plates go right

across the ship from side to side. When they are straight on the upper edge, they may be ordered to a triangular shape if the rise of the floor is great, or to a rectangular shape if it is small. More often, the floor-plates are butted at, or, alternately, at each side of, the centre line. The ordering of the end floor-plates is most conveniently made from the scrieve board, where the exact triangular or trapezoidal form is shown to full size. The floors at the bulkheads are deeper than the remainder, and are usually ordered separately. The two sides of the vessel being alike, the order for the frames, reversed frames and floor-plates for the one side is a duplicate of the other, except where the floor-plates are of unequal lengths. In ordering any kind of material for a ship, care must be taken to specify it to be marked by the steel-makers, so that it can be readily identified when it arrives in the shipyard. The vessel's number must, first of all, be on every plate and angle, and next, a mark signifying where they are intended for—say, for instance, R.F. No. 39 for reversed frame on frame 39, or Fl. No. 77 for the floor-plate on No. 77.

51 BENT FLOOR PLATE

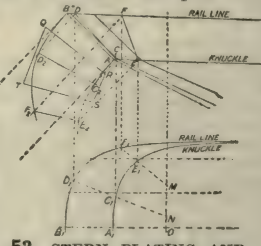
Outside Plating. Great care should be taken in ordering the outside plating, as it is one of the most expensive items in the vessel, and at the same time one of the most difficult to order correctly. The widths of the strakes are shown on the midship section and the model, but they are better obtained from the scrieve board, as the former cannot be depended upon to be exact enough. The lengths of the plates, however, can be obtained only from the model, as, owing to the curvature of the ship's surface it would not appear correctly in any of the views shown by the various drawings. Care must be taken in measuring these lengths to allow for the bend and twist in the plates, and both sides must be measured to see which is the longer. For the midship flat part of the vessel, the length of the plate can be ordered to very nearly the neat size required, but near the ends of the vessel, where the curvature and the twist becomes greater, it is necessary to make a considerable allowance for contingencies in the working of the plate. Some of the plates may have considerable curvature in their edges, in which case it is necessary in ordering to a rectangular or trapezoidal plate, from which they are to be cut, to allow for the round in the convex side by adding to the breadth obtained from the scrieve board for the ends of the plate.

Expansion of Plating. In some instances the outside plating may be of such a character that it cannot be ordered directly from drawings which represent projected views only. The working model shows in all cases the form of the plates, but owing to its small scale, it cannot be relied upon for exact measurements when the curvature of the plating is great. Even if the dimensions, as shown on the model, were correct, it would be difficult to measure them on the bent surface. It is therefore sometimes necessary to draw an expanded view of such plating, in order that the real size of the individual plates may appear in a plane view, where their proper dimensions can be measured. A plate which is curved in two directions cannot be expanded exactly, but, as already pointed out, the individual plates of the outside shell of a ship have practically only curvature in one direction. The plating of the stern or counter of a ship is of such a complex nature, and it is necessary to develop it from its various correct sections as obtained from the final loft offsets. The surface of this plating is, fortunately, in practically all cases truly cylindrical—that is, it is curved in one direction only, and it can therefore always be correctly developed. The form of the stern is given by its elevation and plan views, as shown in 52. The counter, being merely the termination of the vessel at the after end, must be considered only as a part of the hull proper in the fairing of its lines. The stern is a very prominent feature of a ship, and much of the graceful appearance of a vessel depends upon its satisfactory form, and its being in harmony with the remainder of the vessel. There must be no discontinuity in the buttock lines, where the stern joins the hull; at the knuckle line there is a change in their direction, but they are usually nearly straight on both sides of this line. When the form of the stern has been determined, and its lines have been arranged to run fair with those of the remainder of the vessel, then it may be dealt with separately in the arranging of its frames, beams, and plating.



52. EXPANSION OF STERN PLATING

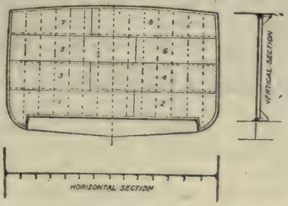
Elliptical Stern. Figure **52** shows an ordinary so-called elliptical stern, the surface of which is truly cylindrical with a more or less elliptical cross section, and with its axis inclined to an angle of about 45° to the vertical. The elevation and plan views of the deck and knuckle line are simply the vertical and horizontal projections of the intersection of the planes of the deck and knuckle with the surface of the cylinder. The buttock lines beween the knuckle and deck lines are generators of the cylinder, being lines of intersection between the surface and planes parallel to its axis. To be able to order the stern plating, it is necessary to obtain its true form, which may be done as follows: The line AB in the elevation of **52** is prolonged upwards, and lines are drawn at right angles to it at K and L, so that BK and KL are equal to the distance between the buttock planes, or equal to ON and NM in the plan view. The buttock line CD, which is also a generating line, is prolonged until it meets the line through K in G_1, and EF is similarly prolonged until it meets the line through L in H_1. A fair line through G_1H_1 and other similarly obtained points, gives the form of a cross section of a plane at right angles to the cylindrical surface of the stern. Draw lines at A and B at right angles to AB, and set off along these BG_2 and BH_2, equal to BG and BH, respectively, which represent the true lengths along the surface from B to the respective generating



53. STERN PLATING AND FRAMES

lines. Draw lines through G_2 and H_2 parallel to BA. These will then represent the generating lines DC and FE on the expanded surface. Square over the points D and C to D_2 and C_2 respectively and F and E to F_2 and E_2 respectively; then fair lines drawn through the points B, D_2, F_2, and A, C_2, E_2, will represent the bounding lines of the expanded stern plating. It will be noted that the expanding of the surface of the stern plating merely consists in the unrolling of the plating so as to be able to obtain its form in a plane surface. Fewer lines than would be necessary in actual practice have been used here for the sake of clearness, but it will be evident that the entire surface of the stern plating can be accurately obtained in this way.

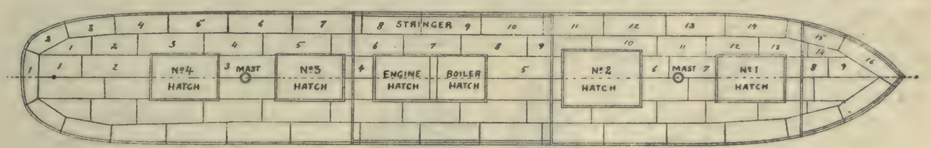
Counter Frames and Beams. The frames and beams of the counter are usually arranged diagonally more or less at right angles to the plan view of the deck and knuckle lines, say D_1N and F_1M [53], and they butt against the transom plate, which is a deep athwartship floor-plate, attached to the sternpost, and is represented by the line OM [53]. When the lines of the frame have been determined in plan view, the points D_1, F_1 and C_1, E_1 are easily squared up and the vertical projections obtained in the elevation. The points D and C and F and E thus obtained may be squared over to the developed deck and knuckle lines, when the expanded lines of the frames may be drawn. The joints of the stern plating are arranged to come between the frame stiffeners, and when the lines of the latter have been drawn on the expanded surface of the plating, it is an easy matter to arrange the former. The true form of the required plates is therefore obtained, and the necessary material can be ordered, with the usual allowance for contingencies. QTRS [53] may represent one of the stern plates with the frame line D_2C_2 running along its centre.



54. WATERTIGHT BULKHEAD

Construction Plans. As soon as the lines have been faired, all the various plans showing the construction of the vessel may be proceeded with, such as the bulkhead, deck and stringer and inner bottom plans. A bulkhead plan is simply a drawing showing the disposition of the plating and stiffeners of a transverse watertight bulkhead, such as is shown in 54. It is usually to a scale of ¼ in. equal to 1 in. The exact outline of each bulkhead is obtained from the line plan, and the landings and butts having been arranged, the plates can be easily ordered to suit the required sizes. The stiffeners are arranged either vertically or horizontally, or in both directions; and their lengths are easily measured on the plan. The bulkhead frames consist, as a rule, of double angles, and they are ordered with ordinary frames. The plans of the iron or steel decks and beam stringers are drawings showing in plan view the arrangement of all the plates and angles with butts, etc., on the various tiers of beams. Such a deck plan is illustrated in 55. The length and breadth of each plate being shown in correct sizes, the dimensions for ordering are easily obtained. The lengths of the various stringer angles may also be readily measured on the deck plan, as may also the lengths for ordering the beams. A plan of a tank top or inner bottom is practically similar to that of a deck, and the plating can be ordered in exactly the same way. For keelson and stringers in hold, a plan is not usually necessary for ordering the material. The arrangement of butts and the lengths of the angles and intercostal plates can, as a rule, be obtained with sufficient accuracy from the model of the vessel.

Ordering of Minor Items. When all the steel for the main structure has been ordered there still remains a large number of minor items for which material is required. The ordering of this is proceeded with as the detailed drawings are being prepared. In some instances where, as in the case of beam knee brackets, intercostal plates, etc., a very large number of small pieces of plates of a given form are required, they may be ordered by templates, which means that a wood pattern is made to full size and to the exact form of the plate required. They are sent to the steel-makers, who can then supply the items in the exact form in which they are going into the ship, whereby all waste of unnecessary material is avoided. In all shipyards there is always a considerable stock of plates and angles of the most common sizes required, and it is therefore unnecessary in many cases to order material from the steel-makers. The workmen may simply be referred to the stock in the yard. The ordering of the stern frame, rudder, stem, and all other forgings or castings, must be done as soon as possible, as it may possibly take a considerable time before they can be delivered, whereby delay may be caused in the building operations in the yard. These items are ordered by exact, complete, and detailed drawings, and in addition, where the design is very intricate, complete full-sized patterns may be supplied for the guidance of the forge or foundry supplying them.



55. PLAN OF A STEEL DECK

Continued

Group 9
DRESS
39
MILLINERY
continued from page 5506

LACE HAT TRIMMINGS

How to Join Lace for Millinery Purposes. Lace Quills and Coquilles. Ruchings and Accordion Pleatings. Lace Fans and Rosettes

By ANTOINETTE MEELBOOM

LACE trimmings are always worn, especially in the spring and summer, in a great variety of ways. They take the form of scarves, medallions of all forms, piece lace draped, or smaller pieces of lace shaped and wired in different fancy shapes, such as quills, fans, coquilles of all forms and sizes, and so on.

One of the first things to learn is to join the lace invisibly, as any cuttings of good lace may be utilised. In covering shapes entirely with lace, it is also important to join the lace neatly wherever pieces have to be cut away or let in to form the curves.

How to Join Lace. Pin the two cut edges over one another, so that the pattern matches exactly [157]. With fine cotton, the texture of the net part of the lace matching it in colour, oversew round the chief lines of the pattern across the lace. Keep to the pattern as much as possible, as the stitches will be invisible at that part. When coming to the net part of lace, each little mesh must have a stitch, and, when correctly joined, they will go in a slightly diagonal direction.


157. JOINING NET LACE

Cut the lace *quite close* to the stitches, no turnings showing on either side of the join.

Lace Quills. To make a lace quill or wing [158], place paper pattern on lace, net, or chiffon, front to cross, and cut out with ¼ in. turnings. If the lace has a pattern, place that in the centre of the quill or wing.

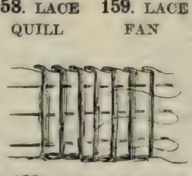
Wire-stitch with lace wire round the edge, turning the ¼ in. turning over the wire on the right side, and allow 2 in. to 3 in. of wire at each end, at the bottom, to form a stem. Finish it with a plain or fancy straw edge, ruching of chiffon, millinery jet or lace edging, which will prevent the turning from showing.


158. LACE QUILL


159. LACE FAN

Pretty quills can be made of insertion lace.

A Lace Fan. The length required to make a lace fan depends on the fineness and depth of the lace to be used [159]. Lace 5 in. deep and 15 in. long will make a pretty little fan for a toque or bonnet.


160. KILTING LACE

Slope the 15 in. to 10 in. at the lower edge. Join it in a round. Nip round the wire ½ in. at the top to prevent the sharp edge tearing the lace. Wire-stitch the wire to the lace, the stitches just fitting round the wire; finish it off securely at the bottom, allowing 2 in. or 3 in. beyond the lace. Place one wire at the join, one in the centre, and one between the centre and ends.

If a pattern has scollops or points at one edge, make the wire supports come in the centre of one of these, always beginning ½ in. from the edge, firmly sewing the loop of the wire to the lace. Nothing is so unsightly as ends of wire standing up above a lace trimming.

Whip round the bottom edge, arrange in a pretty shape, and bind the cotton round the wire ends at bottom. Little fancy lace pins are used to keep the lace in place, pinned in about the middle here and there. Lace may also be wired the way of the selvedge, two or three rows of tucks run in, lace wire inserted and the lace drawn up, thus making a pretty trimming.

Coquilles. Coquilles are made in a similar way. A piece of wire about 6 in. long is left at one edge, and the other wires are arranged on to it, thus forming a kind of cascade. The lace is kept in place with a little fancy lace pin in various places.

Kilted Lace. Kilted lace can be bought machine-made, but often a milliner may have a short piece of lace ribbon or silk to kilt, just for a small cockade bow or chou. If she has not her own kilting machine, it can easily be done by hand [160].

Thread three or four needles, according to the width of the lace, with soft cotton. Pleat the lace evenly, the pleats depending in width on the thickness of the lace. For a pointed edge lace keep the points defined.

Tack the pleats, beginning from the top, using all the needles in turn when a few pleats have been made. Keep them quite straight, and let each pleat just meet the last. Press them on the wrong side with a warm iron, between tissue paper. Take out the tackings by cutting the cotton at frequent intervals.

Ribbons, pieces of silk, and other material may be treated in the same way, and to the width the machine will take.

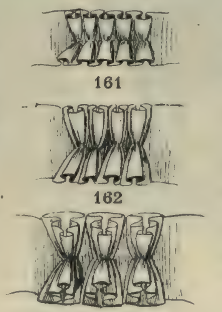
Accordion Pleating. Accordion pleating is different from kilting, as in the latter each pleat just meets, while in the first all the pleats are at the top of one another. It can easily be done at home for millinery purposes with an accordion pleating machine of medium size. Join the lengths, press the seams, machine the lace or any other kind of edging to both the edges, pleat and press in the machine, and cut afterwards to the different widths required. For accordion pleating, six times as much as is required when finished will be wanted.

Ruchings. Ruchings of lace, tulle, net, or ribbon insertion lace with the two edges alike may also be used, or piece lace finished at ends with baby ribbon and fancy edging ; or two narrow pieces of lace may be sewn together by their straight edges.

Ruchings are merely a succession of box-pleats, either single, double, or treble [**161, 162, 163**], or even as many as five or six pleats at the top of one another may be used. They are gathered or pleated in the centre, leaving the edges free.

Make a pleat towards you, and another exactly on the top, and two in the opposite direction. Each pleat must be the same size, and each set of pleats just meet the last. When finished, the edges are caught together.

For single box-pleats, allow three times the length wanted [**161**]. For double box-pleats, allow five times [**162**] ; for knife pleating, allow two and a half times the length needed. Tulle ruchings pleat into one-sixth of the measurement. Tulle or net ruchings are usually cut double the width required, the cut edges coming in the centre. For fine makes of net, five times the length is required.



161 162 163

161–163. LACE RUCHING

Narrow tulle or chiffon ruchings should be about $\frac{3}{4}$ in. wide when finished. Run them through the centre, catching the cut edges. Box-pleating is ineffective in so narrow a width.

Lace and Net Quillings. Quillings are used for cap fronts or as trimmings for hats and children's millinery. They are made with a succession of single box-pleats, each pleat overlapping the last alternately at front and back. For quillings, allow four times the length required.

Quillings of tulle for hat ruches look best when cut the lengthways of the tulle, thus avoiding joins, and giving the better result.

Cut the tulle in strips of about 5 in. wide; fold it in half; hold lightly the two cut edges, and make the quilling as described above, securing each pleat as it is made.

After some practice quilling can be done quite quickly. Light handling, cool fingers, and great care to keep the ruching the same width and the pleats the same size for the whole length, are essential to a successful result. When sewing on quillings or ruchings of tulle, net or chiffon, or any other transparent material that crushes easily, sew on from the back or between the pleats. This requires great care, as lightness of touch is essential with all such work, or it will become crushed in the sewing-on process.

Ribbon and silk ruchings may be sewn from the outside or between the pleats, and the stitches taken through to the upper side. Some ruchings are made on a narrow piece of ribbon, and sewn to the shape by that means.

Lace Rosettes. For rosettes, whip the lace in the centre or at the edge, and arrange similarly to tulle and net rosettes.

Lace Lappets. Lace lappets are used for old ladies' bonnets and caps. They take from $1\frac{1}{2}$ yd. of lace each. Oversew the two edges together, beginning from the cut ends [**166**]. Fold up the triangular piece [**167**] at the end, and cut the lace underneath close to the fold [**167**]. Cut through the fold, obtaining thus the little triangular piece of lace without a join [**167A**]. Place this piece in the triangular place as shown in **168**, and join carefully, as for joining lace [**157**].

Figure **168B** shows a piece of lace left with join in the centre.

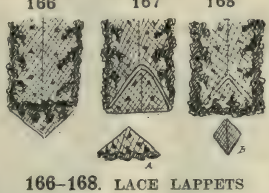
Joining Light Materials. To join tulle or net, overlap the edges for about 1 in., pin and tack. When the trimming is complete, take out the tacking stitches, and the join will be invisible and quite firm [**164**]. To join chiffon, turn in about $\frac{1}{4}$ in. at cut edges, dovetail them together, and tack [**165**]. Lace, net and chiffon veils of all kinds are sometimes worn as a trimming for hats. They can be made of a fine make of net, with a small pattern edged with narrow kilted lace, velvet ribbon, or narrow ruchings.

The net or lace can be obtained in almost any colour and looks well edged with another colour or a deeper tone of the same shade.

In the making the worker should be careful to ease the lace at the corner, or, when velvet ribbon is used, to turn it in sufficiently. The drapery will not set well if it is at all tightened. The edges of chiffon veils are turned in twice and neatly run with silk to match.

164 165

164-165. JOINING LACE FOR LAPPETS



166 167 168

166–168. LACE LAPPETS

At the present time veils are a very fashionable trimming, and if arranged artistically, make a charming, and to many people a particularly becoming, finish to a hat. But the milliner should remember that nothing can give an appearance of bad style so easily as a badly arranged veil which is too long and which droops over the shoulder in a heavy mass.

A small lace veil carelessly draped round a neat travelling hat which boasts nothing else in the way of trimming but, for instance, a bird's wing wonderfully softens and improves the general effect.

Such veils, of course, are fixed with small fancy pins, which fasten them quite as securely as, and far more effectively than, stitches.

The small veils used to trim travelling hats are of white or cream net, with a border and ends of lace.

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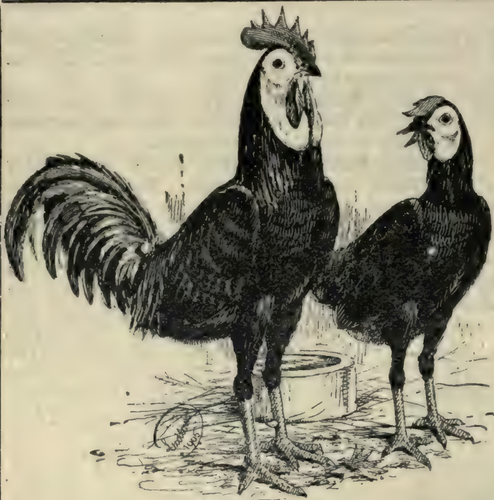

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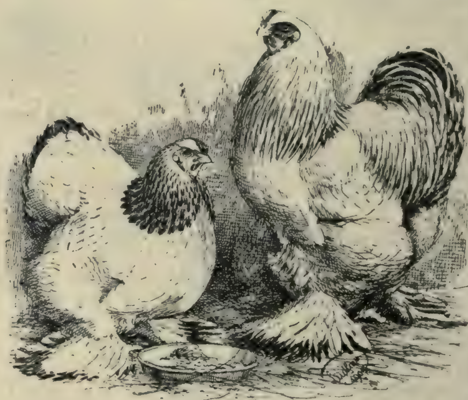

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69

70

BREEDS OF POULTRY

65. Spanish **66.** Frizzles **67.** Dark Brahmas **68.** Light Brahmas **69.** Silkies **70.** Partridge Cochins

BREEDING FOR EGGS & MEAT

Aiming at Egg and Meat Production in Place of Ornament. Good and Bad Breeds. Eggs by Weight. Early Hatching

continued from page 5436

By Professor JAMES LONG

ALTHOUGH poultry are so largely bred for exhibition and for the purpose of gaining prizes, the main object is the production of food for man—eggs and meat. In order to achieve success in this work it is necessary to follow the lines of procedure which breeders of larger stock have now followed for so long a period with such distinct benefit to the whole community.

Achievements of the Ornamental Fowl Breeders. For half a century breeders of poultry for exhibition have mated their birds on the principle of selection. If they desired colour of plumage, symmetry, or size, they have chosen breeding stock which corresponded in the highest degree with their requirements. They have, in a word, bred from the best coloured, the best shaped, and the largest specimens obtainable.

The producer of beef, mutton, or pork selects his breeding stock from among those cattle, sheep, and pigs which, making the most of their food, attain to the greatest weight in the shortest time. The producer of wool employs not the breed which converts its food into mutton the most quickly, but which carries, as its ancestors have also carried, the largest and finest fleece. And so it is with the pure races of poultry. The amateur has, during a long course of years, fixed certain types of form, colour, feather, comb, ear, and other fancy points, although in but few cases has he made, until recently, any attempt to increase the number of actually utilitarian breeds.

The Development of the Brahma. What has been accomplished so successfully by breeders for exhibition, then, can be equally well completed by breeders for meat and eggs. Indeed, we hold the opinion that had one half the energy, persistence, and skill that has been exemplified by the amateur in response to the demands of his hobby been employed on breeding for utility, we should now be in possession of birds which would stand upon the same plane as the Shorthorn among cattle, the Lincoln among sheep, and the large White York among pigs. We may take one instance in point. The Brahma [**67, 68**] came to us from the East a raw, ill-fashioned fowl, as distinct from the bird of to-day as the Aberdeen Angus bullock is from the buffalo ; but the amateur put his back into the work of selection, and obtained a marvellous result. Had he proposed to convert the new breed into a table or laying fowl of great excellence a few years would have sufficed ; but he determined to introduce a superb form of feather marking and colour, and he succeeded, although the time occupied in the process was necessarily much prolonged.

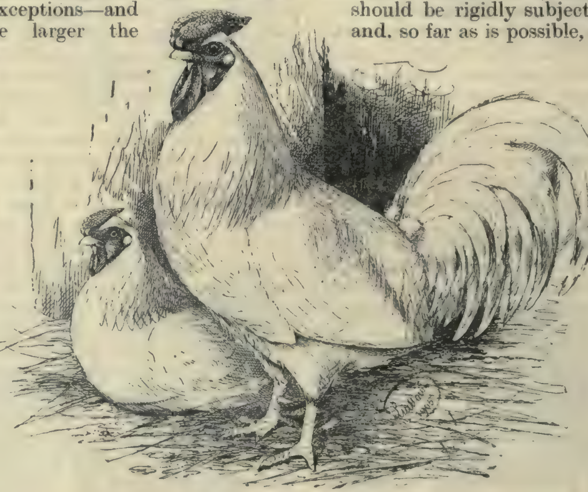
The Value of Crossing Breeds. It is probably quite correct to assume that the best layers, omitting the few birds which have been bred on the principle of selection, and the best table fowls are the result of a cross between two pure breeds. Successful production largely depends on constitution. Pullets bred from two inferior laying breeds—like those the produce of parent stock not remarkable for its vigour on either side—are hardier and lay better than the hens of those breeds. Crossing provides a fillip to the constitution of the produce. The Dorking [**7**, page 4855, and **71**], like the Brahma, is a layer of the second class, but pullets produced by crossing the two breeds lay better than either. The Flèche fowl [**18**] is delicate in constitution, and although a layer of large eggs, those eggs are not very numerous. If, however, we cross the Flèche with a breed of similar character, we obtain hardy birds, and a larger number of eggs. Thus it is that for some years a newly manufactured breed like the Wyandotte [**13**], the Plymouth Rock [**12**], or the Orpington [**14**] does good work. It is the product of a variety of crosses; it draws upon the constitution of each breed employed; it is hardy, fertile, and productive. In course of time, however, it follows the example of breeds which have preceded it, as the Cochin [**70**], the Brahma, or the Spanish [**65**], and unless sustained by selection and the consequent introduction of blood intended to maintain its constitution, and to improve its productive powers, it loses its utilitarian properties and is lost in the crowd of useless breeds.

Purity of Breed Unnecessary. Let us next point out what is involved in the selection of breeding stock for the production of eggs and meat. The breeder may determine to adhere to a pure breed, or he may discard sustained purity altogether and make his selection from what source or sources he chooses. There is, however, no object in sustaining purity of breed. The egg from a highly-bred Indian Game [**20**, page 4954] hen is no more valuable than that from a barn-door fowl. The cross-bred Dorking Game capon is equal to a capon of any pure race, and infinitely superior to the great majority, and the remark applies to the table bird of every class.

Thus far the way is clear. How, then, should the breeder start ? If he desires to obtain eggs his course is clear—he should strike out a line for himself and follow it with pertinacity. He will purchase large-framed hens of a breed or colour to suit his taste, taking care that they have not passed their second year, that they are in robust condition, and that they are, as far as he can judge or ascertain, layers of a large number of buff eggs,

for the public prefer a tinted to a white egg. Since the establishment of laying competitions a number of breeders have made a point of testing their hens and recording the number of eggs they lay. Trap nests, which close automatically as the hen enters, are employed. She is liberated by her owner or his assistant and, being recognised, is credited with the egg she has laid. By this means it becomes possible to select the best layers from the flock, and to retain them for the next season's breeding. The male bird intended for mating with these hens should be a son of the best-known layer, conditionally upon his being typical and full of lusty life. Size is not so important in the case of the cock as of the hen; but he should be above the average. The larger the hen the larger the egg—although the rule has exceptions—and consequently the larger the chicken. As the practice proceeds it will become a natural method of procedure to select the cockerel intended for stock from the produce of the best laying hen, and so on from year to year.

Value of the Cockerel. As the practice of utilitarian breeding extends buyers will be much more willing to pay £10 for a cockerel the produce of a hen which has laid 250 eggs within her year than for a show bird of great perfection. Cattle have realised thousands of pounds, and sheep over a thousand guineas a head solely for the reproduction of stock intended for beef and mutton. It is among poultry alone that we find animals intended by nature as food producers, bred and fed to please the eye instead of to satisfy the palate. Why, then, should not the poultry breeder make utilitarian production his aim?



71. WHITE DORKINGS

Some Useless Breeds. It is important to guard against imperfections. For example, birds of small size, whether they are of pure breed or no breed at all, must be avoided: the hens produce small eggs, while the chickens provide but little meat. Again, birds of those varieties which have lost every utilitarian qualification—if, indeed, they ever possessed any—are equally useless. We refer to the Polish [3, 81, and 82], Sultans [80], Spanish, Cochins, Aseels [40, page 5089], and all breeds of similar type. Nor is it quite worth while to risk the Leghorns [23], much as they are praised, for the reason that they are undersized, and therefore little adapted to the production of an abundance of meat or of eggs of large size.

Buying Eggs by Weight. It should be remembered that if eggs are not bought by weight directly from the producer in our own country, the practice obtains in Denmark, where egg culture is more highly organised than in any other country in the world, and with time it is certain to become general. In British trade the larger the egg the higher the price the retailer pays for it, although he seldom makes any reduction in his charge when his goods are small. The producer, however, who seeks to succeed will make a point of charging higher prices to his private customers for the large eggs he produces, and he should aim at excluding anything weighing less than 2 oz., or eight to the pound.

Points About Table Fowls. In the case of table fowls, every bird intended for stock should be rigidly subjected to examination, and, so far as is possible, some recent history of her ancestors should be obtained. Although buyers are not so prejudiced against coloured skin and feet as formerly, whiteness of both should be assured, for skin tinted like the palm of a lady's hand is preferred by the high-class dealer, the cook, and the lover of a delicate part of the carcase. Whiteness usually indicates quality, especially in the Dorking and the English Game [41]. Again, the breast must be straight, broad, and deep, that it may carry abundance of fine meat. A table fowl, in a word, should be large, white-skinned, and fully developed in those parts of the carcase where the most tender meat is found—the breast, merrythought, and wing. Such birds carry much less offal than the inferior table breeds, such as the Cochin and Brahma, both of which possess large frames, with a correspondingly small quantity of meat, while the bones, skin, and intestines weigh much more than they should do.

Avoidance of Inferior Birds. Now, it is evident that if we would ensure quantity and quality of meat we can only obtain it by following the practice already suggested—selecting our breeding stock on both sides from among those birds which are specially excellent in relation to both qualifications. Nothing should be left to chance. To use an inferior bird is to court certain failure. In all cases, however good the parent stock may be, we are certain to obtain a large percentage of second-rate specimens. How much more unlikely it is, therefore, if we breed from stock which possesses few,

BANTAMS AND OTHER SMALL BREEDS

72. Japanese Bantams 73. Black Red Game Bantams 74. White-booted Bantams 75. Silver Sebright Bantams 76. Pekin Bantams 77. Black Rosecomb Bantams 78. Malay Bantams (spangled) 79. Tailless 80. Sultans 81, White Polish Bantams

if any, essential qualifications, that we should obtain any produce adapted to our particular purpose.

Chickens Should be Hatched Early. In breeding for market or egg-production it is highly essential to hatch the chickens early. The ordinary poultry-keeper makes no special provision in this direction. He sets his hens in March, April, and May, and sometimes even in June, with the result that the pullets do not arrive at maturity before the arrival of cold weather, and, consequently, they do not begin to lay until February or March in the following year. Thus a bird hatched in May must be fed for some nine months before she begins to make any return. Her first laying year is probably in such a case confined to six months, inasmuch as the moulting season arrives with July, and after moulting few hens lay with any regularity until early spring once more arrives. It is, however, quite uneconomical to keep hens after the moult. They should be sold with its arrival, when they are usually in good condition; otherwise they may have to be kept for six months at a cost which will exceed in value the return they make in eggs. A laying hen among ordinary stock is not worth keeping after she has completed her first year's egg-production, and that year is assumed to be as nearly as possible twelve months. In other words, from the time the pullet begins to lay—some six months after hatching, although the period may be slightly more or less—until she begins to moult as a young hen she should produce her maximum yield. That yield we estimate to average throughout the country 80 eggs, but in the hands of capable people, pullets specially bred from selected stock will lay from 150 eggs upwards if they have been hatched very early. In competition, 250 eggs has been reached, and in many cases from 200 to 220.

82. SILVER POLISH

The Use of the Incubator. If hens for the purpose of hatching are unobtainable, the incubator must be used, and the stock birds having been mated by the end of November, eggs should be obtainable by the first week of January, and work begun. It is, however, wise to keep a good stock of young birds specially bred or purchased for sitting—Dorkings, Wyandottes, Plymouth Rocks, Cochins, Brahmas, Orpingtons, or crosses between any of these breeds. They must necessarily have been early hatched in their turn, because they will not begin to sit until they have laid a batch of eggs. The male bird used should be an early-hatched cockerel, for if an older bird is chosen there may be many infertile eggs in the very early months. Similarly, the females should be early pullets, although, if laying hens a year older are obtainable, so much the better, for the reasons that they produce stronger chickens, while their eggs are larger. Early hatching necessarily involves more trouble in feeding, in protecting, and, generally speaking, in rearing the chickens, since the weather is much less suitable to their requirements than in spring and summer. What, however, has been so successfully overcome by the cattle and sheep breeder can be overcome by the poultry-breeder, who will supply special foods and provide the necessary warmth and shelter. Here, too, we notice the value of the stress which we have laid upon the importance of constitution, for weakly stock will produce still more weakly chickens, which, if hatched, will only die.

Avoid Late Spring for Table Birds. It should now be quite clear to the reader that for the purposes of egg-production young stock must be hatched early. It is, however, equally important that chickens intended for the *table* should be early. As we have seen, the vast majority of the poultry-keepers of the country hatch their chickens in late spring, with the result that the markets are crowded with table birds from September forwards, and prices are consequently low, so low that the profit realised, if any, must be too small to pay for the trouble involved. High prices are only obtainable when the poultry-market is poorly supplied, and this is the case between March and June, although imported birds to a large extent fill up the gap. No chickens, however, can equal the best home-bred and fed, and those who produce the best will, we confidently believe, always be able to obtain remunerative prices during the season. To supply the April and May market chickens should be hatched in December and January, and finished with the cramming process, by which means a large addition will be made to their weight in from two to three weeks. It is essential, however, that they should be of the right blood, inasmuch as birds of the lean and small breeds do not appropriate the food supplied to them with the same excellent results.

Eggs for Hatching. It is important to take care in the selection of eggs for hatching. A small egg cannot produce a large chicken. An abnormally large egg may contain a double yolk, and so fail to produce a normal chicken. Malformed eggs, and eggs the produce of pullets during the week they first begin to lay should also be rejected. We strongly advise the breeder to make a point of rejecting all eggs which fall below 2 oz. in weight, while making every effort to obtain as many as possible which approximate to $2\frac{1}{2}$ oz.

Continued

INTERNAL PLUMBING

Lead and other Work for Internal House Plumbing. Wiped and other Joints. Internal Water Supply. Cisterns, Taps, Sinks, Baths and Closets

Continued from page 5502

By Professor R. ELSEY SMITH.

THE work of the internal plumber is mainly connected with the supply of water to the building, its distribution to the various fittings by means of pipes, and the installation of these fittings, with the necessary precautions to prevent damage to the building from overflows or other accidents. The work includes the preparation of some fittings; but, for the most part, fittings are supplied by special manufacturers to the plumber complete, with instructions as to fixing. The principal tools used by the plumber have already been described [page 5030], and we may proceed, therefore, at once to the important subject of pipes and joint-making.

The pipes used by the plumber are either of lead or iron for most purposes, though copper pipes are also used.

Lead Pipes. *Lead pipes* produced by hydraulic machinery are known as *drawn pipes*, and are in almost universal use. Pipes having the same internal diameter are drawn of various thicknesses of metal, and are described by their weight per yard run. The following table gives the approximate weights of pipes of various diameters known as *strong*, *middling*, and *light*; but these weights are not uniform. The requirements of different water companies are apt to vary as to these weights, and should always be carefully ascertained before work is begun.

Internal diameter.	Weights in pounds per yard run.		
	Strong.	Middling.	Light.
in.			
$\frac{3}{8}$	5	—	—
$\frac{1}{2}$	6	$4\frac{1}{2}$	$3\frac{1}{2}$
$\frac{3}{4}$	9	$7\frac{1}{4}$	$5\frac{1}{2}$
1	12	$10\frac{1}{2}$	$8\frac{1}{2}$
$1\frac{1}{4}$	16	14	12
$1\frac{1}{2}$	18	16	—
2	24	21	—

Strong pipes are required for all pipes charged from the companies' mains, and in cases where a considerable head of water exists in service pipes. *Middling* pipes may be used for ordinary service pipes and for wastes. *Light* pipes are principally used for overflows with open ends and for services in inferior work.

Iron Pipes. *Iron pipes* are very generally used for the *rising main* conveying the water from the water company's main to the cistern, and may be used for service pipes; they are also used for all hot-water services. They may be the ordinary black pipe, but such pipes are apt to rust internally and to discolour water passing through them, consequently galvanised iron pipes are preferable. The pipes used are known as *wrought-iron welded steam tubing;* the ends are screwed, and union sockets are the most convenient as allowing of ready disconnection [**2**]; but pipes with socketed ends are also used. Tees, bends, sockets, reducing sockets, angles, etc., have to be provided for fitting up the pipes, and they may be fixed to the walls by means of wall hooks. Patent clips are also used. These are pinned into the wall, and have a ring, half of which is hinged so that the pipe can be inserted and then gripped, and it is thus held a short distance from the wall face. Cold pipes may be fixed against woodwork with an iron or brass band passed round the tube and screwed to the woodwork [**1**]; but no hot-water pipes should be in contact with woodwork. The joints in iron pipes are made with some strands of tow and red lead as packing, and are screwed up tightly.

Copper Pipes. *Copper pipes* are used in very high-class work, and also have screwed ends; the unions, elbows, etc., are made in gun-metal. The joints may be made with graphite or with red lead. Where used for hot water, pipes should not be so rigidly fixed that they are not free to expand and contract; and in positions where the necessary fixing precludes the possibility of the pipes having such play, a loop may be formed in the pipe to permit of such movement. This is a better arrangement than any form of ordinary expansion joint for service pipes under pressure.

Jointing Lead Pipes. There are various methods of jointing lead pipes; of these the *wiped joint* is perhaps the most usual plumbers' joint, but the *copper bit joint* and the *blown joint* are useful for many purposes. In preparing for making the copper bit joint, the bit itself, which is of the hatchet form [**67**, page 5030], must be properly tinned.

Tinning the copper bit consists in covering the end of it with solder, giving it the appearance of being tinned. This is done with the same flux as is to be employed in the work to be soldered. For lead work this is usually *black resin*; for iron, brass, copper, etc., *killed spirit* is used—this consists of spirits of salts into which has been dropped as much zinc as it will dissolve. The end of the bit must be filed perfectly clean and free from any smoke or grease; a small tin plate has a little powdered resin placed upon it, the bit is heated, and a little fine solder melted from a stick and dropped into the pan; the nose of the iron is then rubbed in the mixture and becomes covered with solder, and is ready for use. Where killed spirit is to be employed, the heated iron is tinned by dipping the nose for a moment into the spirit and then touching it with a stick of solder. The object of the tinning is to prevent the iron becoming oxidised during heating, which would prevent the perfect contact between the bit and the solder which is essential, and if the bit is heated red hot so that the tinning is destroyed it must be re-formed.

Iron, brass, and copper must be tinned before soldering. The surface is very carefully cleaned and afterwards painted over with the killed spirit, and fine solder is applied to it with the heated iron and becomes amalgamated with it.

Making Copper Bit Joints. The two lead pipes to be joined together must be differently treated. The upper end of one pipe must be opened. This is done by first cutting the pipe squarely across with a saw and cleaning off any roughness from the inner edge; a turnpin [**70**, page 5030] of suitable size is selected and wetted and then placed truly in the opening of the pipe and struck squarely with

the mallet so that it is driven downwards, enlarging the end. If the pipe shows signs of splitting, the edge is beaten with the mallet to thicken it. After it has been opened and the outer face *soiled*, the inner surface is carefully cleaned all round with a shave hook and *touched* with a tallow candle. Care must be taken in shaving to take off only just sufficient metal to ensure a bright surface, but not so much as to reduce the thickness appreciably. The lower end of the upper pipe is prepared by rasping it all round to a bevelled form so that it will fit into the funnel-shaped end of the lower pipe [**4**]; this must be carefully and evenly done, otherwise during soldering the solder may pass between and adhere to the inside and form an obstruction within the pipe. The pipe is afterwards soiled and shaved. In making the joint the two pipes must be rigidly fixed so as to prevent their moving. For many purposes a *wooden cramp* [**5**] is serviceable, which will grip the two pipes and hold them in position; but in some cases a couple of chisels driven into a wall may be used.

When the preparations are complete a little black resin is put in the space between the two pipes and with the prepared bit a little solder is melted off into the joint all round—the nose of the iron is run into the solder, and this is floated round by drawing the hot iron right round the joint, leaving a smooth, true surface.

A *blown joint* is prepared for similarly, but in making this joint the blowpipe is used to melt the solder in place of the iron. A spirit lamp or a bundle of rushes is used to provide the flame. Resin is placed in the joint, and the blowpipe is used to heat the lead of the pipes till it is hot enough to melt the solder without affecting the lead. The joint is then touched with the solder stick, and the solder melted off into the joint. Its temperature is maintained by the blowpipe till the whole of the solder flows and unites with the lead, and the joint is then complete.

These joints are specially serviceable for joining up lead pipes to unions and in similar positions where it may be necessary to pass a lock-nut over the joint, which would be impossible with an ordinary wiped joint.

A variation of this form of joint is the *ribbon joint* [**6**], in which a band of fine solder is formed round the joint about an inch broad and projecting $\frac{3}{16}$ in., which makes a strong, neat finish.

A joint made in this simple form is not desirable in making the joints of soil or light ventilation pipes, as the piping is not strengthened by it as it is by a wiped joint.

Jointing Soil Pipes. External soil pipes may, however, be formed with such a joint; the head of the lower pipe is opened rather wide to allow of a rather thick soldered joint, and the joint is finished with an astragal moulding immediately below [**7**]. These mouldings may be cut out of a small lead pipe, or cast and bent round and soldered to the pipe. A similar astragal is added below the tack, and makes a very neat finish. Sometimes the socket is cast, including the astragals, and the pipes both above and below are soldered or burnt to it.

Wiped Joints. The pipes are prepared in a similar manner for a joint that is to be wiped, but rasping of the upper pipe is made a little longer, and the two pipes must be shaved for a longer space than in the previous case. The extent to which the shaving is carried regulates the length of the joint, and this varies with the diameter of the pipes to be joined. For a $\frac{1}{2}$-in. pipe, the length of the completed joint should be from $2\frac{1}{4}$ in. to $2\frac{3}{4}$ in.; while with a large pipe, 5 in. or 6 in. in diameter, the length may be from $3\frac{1}{2}$ in. to 4 in.

In making *underhand joints* [**10**]—that is to say, joints that are horizontal or slightly inclined, the soiling does not require to be carried so far beyond the shaving line as in the case of an *upright* joint, but should extend at least 3 in.

In all cases where pipes are horizontal, or nearly so, the joint must be made so that the rasped end of the one pipe is inserted into the opened end in the direction in which any liquid in the pipe will flow so that the edge of the pipe shall not form any obstruction. This is particularly important in the case of a soil pipe or any pipe in which there may be solid matter in suspension in the water.

A *pouring-stick* is required for getting solder to positions difficult to reach otherwise, and is a strip of deal about 1 ft. long, with a groove down the centre, the end shaped like a scoop.

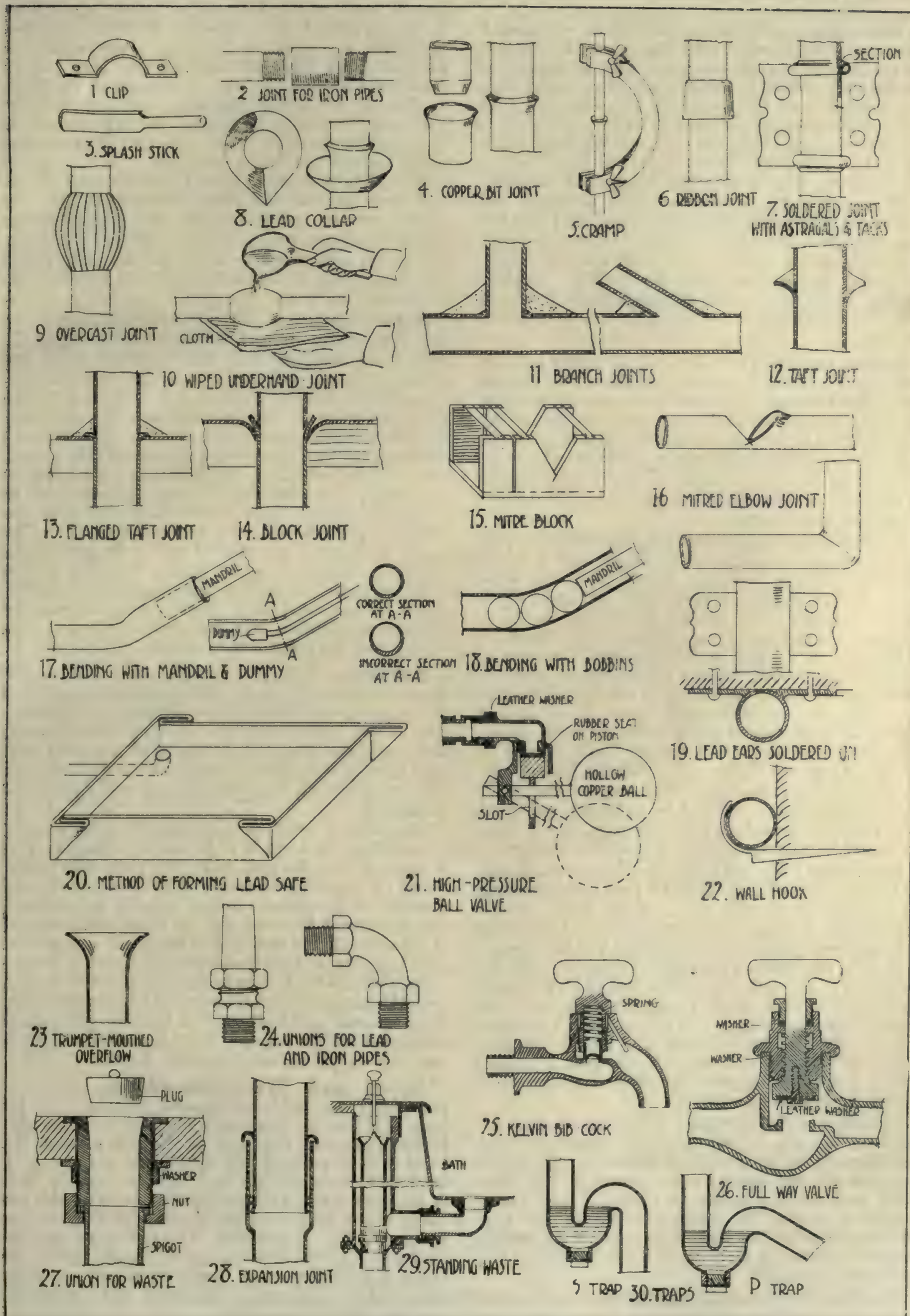
A *splash-stick* is a thin strip of wood, shaped with a handle [**3**], unless solder is to be used so hot that it will burn and smoke; in that case iron may be used, but care must be taken not to scrape the soil from the lead in using it.

Cloths are essential for wiping joints, and the best are made from moleskin or fustian repeatedly folded so as to give a thickness of from six to ten folds, and sewn round the edges. Several of these are required for dealing with joints on pipes of different size. A little melted tallow is poured on to one side of the cloth, and this prevents the solder from sticking to it. The cloth is well warmed just before it is used.

Wiping Underhand Joints. In making underhand joints the cloth is held in the left hand, and the ladle, three parts full of molten solder, in the right [**10**]. This must be at the proper temperature, a knowledge of which is best obtained by experience. It may, however, be gauged by inserting a little piece of newspaper into the solder, which should brown quickly without burning. The solder is poured lightly on to the joint, the ladle being moved to and fro and from side to side; it is also poured on to the soiled part at each end to warm up the lead to the temperature of the solder. The cloth is held so as to catch the solder as it runs off, and to tin thoroughly the underside of the pipe. The cloth, like the ladle, is kept moving, and the solder gets into a uniform soft condition before it sets too firm, and is roughly shaped and should be nearly of the same consistency throughout. When this stage is reached the ladle is put aside, and the joint is at once shaped with the cloth, beginning at the edges next the soiling, where there is least thickness of solder, and finishing on the top; the cloth may be passed from the left hand to the right to get all round the joint. The surface may be finished by passing the cloth lightly all round the joint to give it a smooth and even appearance.

The iron, which must be perfectly clean and well heated, may be used in wiping the joint if necessary, to heat up the solder after the required amount has been formed on the joint, the iron being kept a little in advance of the cloth.

Wiping Upright Joints. In wiping upright joints, a *collar* must be placed round the lower pipe to catch the solder; this may be formed of sheet lead cut to a pear shape, with a central hole the size of the pipe, and a cut from the centre to the point [**8**]. This is fixed round the pipe, the two points being drawn past each other—this giving a slightly cup shape—and folded over to secure the collar. The surface and edges are well soiled, and a piece of stout twine may be fixed two or three times round the pipe as a support to the collar, the surface of



PIPES, JOINTS, AND FITTINGS

which should be only slightly inclined. A little dust is sp inkled in the bottom of the collar to stop up any apertures.

The solder cannot be poured on to an upright joint, but is splashed on with a splash-stick as evenly as possible all round the joint, and is worked as nearly as possible to the shape. Any metal that drops down must be pushed up with the stick, and some solder must be splashed on to the soiling above the joint to warm the pipe; that which drops down on to the collar will warm the lower pipe. When the requisite amount of solder is splashed on and is of the right temperature, the cloth, which is well heated, is first taken in the left hand, and first the top, then the bottom, and then the centre of the joint is rapidly wiped round on one side, and afterwards the other side is done with the cloth in the right hand. As in the case of the underhand joint, an iron may be used, if necessary, to heat up the solder for wiping.

Overcast Joint. A wiped joint may be *overcast*. This consists in warming up the solder with an iron; then the neck of the iron is drawn up and down over the surface, so as to form a series of facets [**9**]. The object is to re-melt the solder, and if it is cellular and porous, which coarse solder is liable to become, to fill up the pores, and to get rid of any irregularities in the surface. The result is to give the joint a ribbed or striped appearance.

A *branch joint* [**11**] is one uniting the end of one pipe with the side of another at an angle, and it is not essential that the two pipes should be of the same size; it is desirable, especially in the case of all pipes in which solid matter as well as liquid is carried, that the angle made between the two pipes should not be a right angle, but should be one to secure an easy flow. In the case of water services, however, it is often necessary to use a right-angled junction, and, if well made, there is no serious objection in the case of pipes under pressure. Great care must be given to the fitting of the joint, and on no account should the spigot end of the branch pipe be allowed to project into the bore of the main pipe; neither should its end be enlarged and fitted over a socket formed on the main pipe, but it must be rasped to fit accurately within such a socket.

The socket is formed by perforating the main pipe at the side, and with the *bolt* [**74**, page 5030] working up the lead all round in the form of a socket, which will receive the spigot end of the branch. In the case of a right-angled junction, the socket will be circular, but with an oblique junction the socket will be elongated; the end of the branch must be kept well up to ensure that it shall not interfere with the flow in the main pipe. The two pipes are securely fixed in position, and the solder is then worked on with a splash-stick and wiped much as in a vertical joint; the solder must be splashed over the soiled end of the branch to warm the lead.

The *taft joint* [**12**] resembles in its form a copper bit joint, but is a wiped joint made in coarse solder, and can be made by an unskilled workman. The lower pipe has the end opened with a turnpin, and then *tafted* back with a mallet to form a flange either curved in section or sometimes flat in the top. The spigot end of the other pipe is fitted by rasping it, and the joint is then made by splashing on the solder and wiping it.

The *flanged taft joint* [**13**] resembles the last, but has a flange of lead formed under the tafted edge, and included in the joint. This is useful where a pipe is brought through a floor, which can be used as a support to it.

The Block Joint. *The block joint* [**14**] is another form of joint closely allied to the last, and is used where tall soil or other pipes have to be supported in a chase. A block of wood, usually 3 in. thick, is built into the wall, and perforated so that the end of the pipe can be passed up through it; the upper side of the block is dished, or slightly hollowed, and a lead flange is dressed down into the hollow, and is perforated so as to just fit round the main pipe, and the surface is soiled beyond the line of the joint. The upper end of the pipe is shaved, passed through the flange, and then opened out with the turnpin, and the inside shaved; and the upper pipe is prepared as usual, taking care to shave it for a sufficient distance. The solder is then splashed on, and the joint wiped, the joint and its supporting flange forming one solid piece of work.

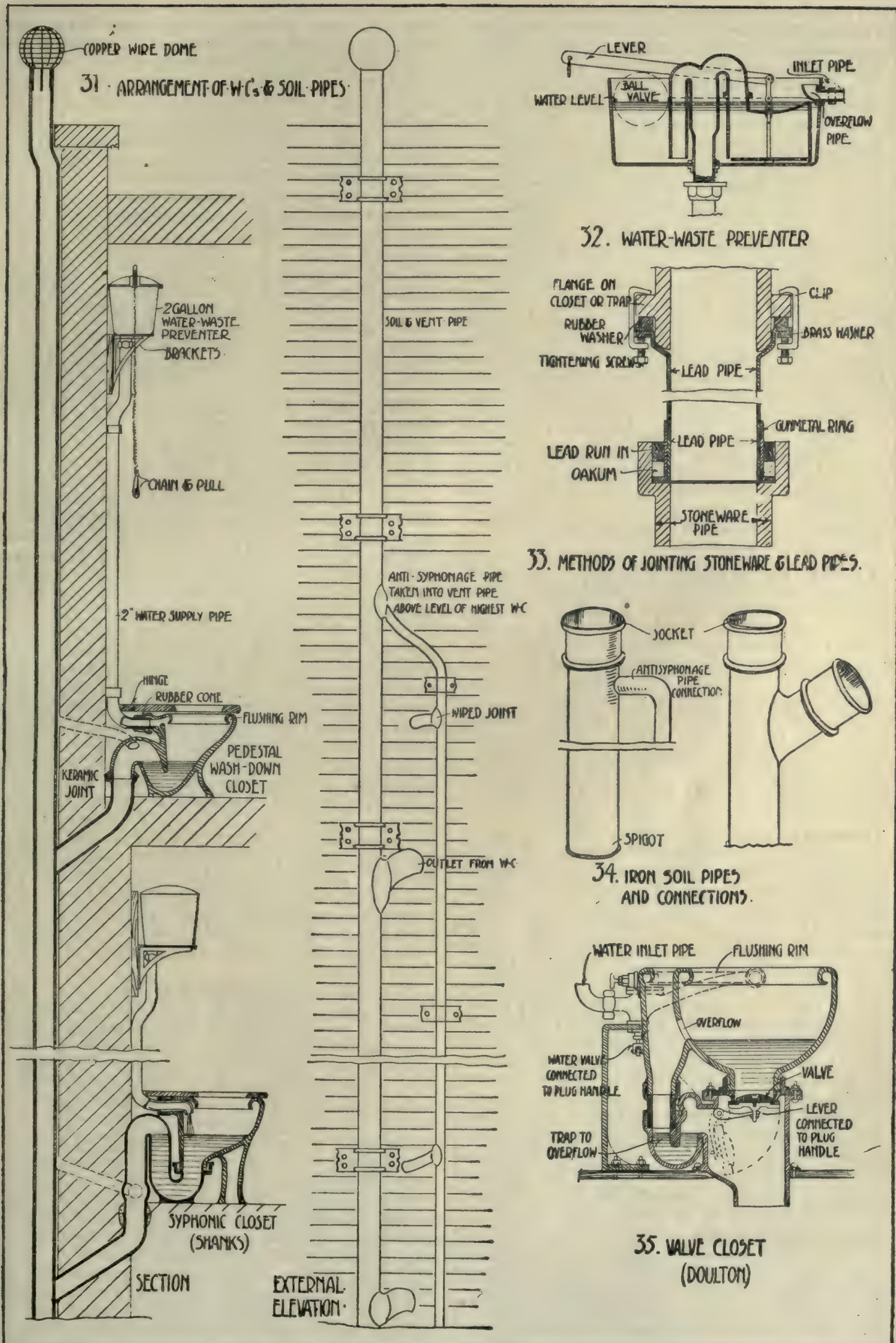
Elbow Joints. When a sharp bend is required in a pipe it may be produced either by cutting the pipe or by bending. The latter is more usual, and in many respects better; but a *mitred elbow* [**16**] may be used in rainwater work, and if fixed in the right direction, even in certain positions in a soil pipe, though it is better to avoid its use. In making a right-angled bend a *plumber's mitre block* [**15**] is used, and a V-shaped piece cut from the pipe. One of the edges is dressed up so that the other will fit inside it, and the pipe is then soiled all round for some distance beyond the cut on each side. The edges of the cut are shaved so as to give, when closed, a joint about $1\frac{1}{2}$ in. wide; the joint is then bent up, but must not be bent backwards and forwards or the head may crack; it is temporarily secured in position, and the sides of the joint are closed, and the joint is then wiped.

Bending Pipes. Considerable skill is required in this operation. The principal danger in it is, first, that the pipe may be crippled at the bend—that is, the bore of the pipe may be reduced in area; and, secondly, that the thickness of the lead itself may become reduced, especially at the heel or outer side of the bend, and the lead in consequence be weakened.

In making a bend, the pipe must be heated at the point where the bend is to be made; a mandrel [**17**] is inserted into the end, and the pipe is then pulled round till the *throat* or inside of the curve is slightly dented. A hot dummy is then inserted in the bend, and the throat knocked out till quite round again; in the sides, if they are inclined to spread, are knocked with a dresser, and the lead from the throat is worked round towards the *heel*, or back of the curve, so that an even thickness of lead is maintained all round the pipe. This operation of heating and bending the pipe is continued till the required bend is arrived at, but it must be a gradual, not a sudden process.

Sand and Water Bending. Sand is sometimes used in bending, and is serviceable for long, easy bends. The pipe is filled with sand, which is incompressible, the sand at the point where the bend is to be made is put in hot, and the pipe may be pulled round and dressed. Water may be used in the same way. One end of the pipe is closed, the other fitted with a stopcock, and the water is run in hot till the pipe is full. The pipe may then be bent and dressed, but this must be done before the water has time to chill down, or it will contract. Should this occur, some additional water must be run through the stopcock.

Bending with Bobbins. This is used for small pipes. The balls require to be a trifle less in diameter than the bore of the pipe. The pipe is pulled



SANITARY FITTINGS AND THEIR CONNECTIONS

round till it begins to flatten, then the ball is inserted and driven through with a short mandrel, but great care is necessary not to drive it through the lead [18].

Where a twisted bend occurs in a soil pipe, care must be taken not to allow any part of the pipe to become horizontal, but a regular fall must be secured throughout all parts of it.

Fixing Pipes. Pipes that are to be fixed vertically are fixed by means of *tacks* [7]; these are small sheets of lead, which may be plain or treated ornamentally. They are soldered to the back of the pipe, and project on one or both sides. The edge of the tack is rasped so as to lie against the pipe, and then soldered on. These may be soldered in pairs, one on each side of the pipe, and the lead used for such tack should be slightly heavier in quality than the lead of the pipe itself. A heavy ten-foot length of pipe may be supported by two pairs of tacks or by three single tacks placed right and left alternately. Ornamental tacks are sometimes cast in a mould and soldered to the pipes in the same way, and lead *ears* are also employed [19]. These are less in depth, and not so strong, but may be treated in an ornamental manner. Both tacks and bars are secured to the wall by spikes, and the edges of tacks are sometimes cut and rolled in a spiral form as an ornamental treatment. Service pipes may be supported by small tacks; these are secured to the walls by nails or spikes.

Fixing Horizontal Pipes. All pipes, whether service or waste pipes, should be fixed with a slight fall, so that they may on occasion be emptied. They are very often fixed with *wall hooks* [22] placed at short intervals, and driven into the wall; these are liable to indent the pipe where they grip it, and do not support the intermediate parts. A better method of fixing is to rest the pipe on a bearer formed of a strip of board. In fixing all runs of pipes it is desirable that they should be in situations where they are not likely to be readily frozen in severe weather; they should be placed, therefore, as far as possible, on internal rather than external walls.

Cisterns. Cisterns can be obtained made of various materials—slate, galvanised iron, and lead—either cast or used as a lining to a wood casing. Slate cisterns are excellent, but heavy and costly; galvanised cast iron is the material now in very general use for cisterns, which can be obtained in stock sizes of various makes, or can be specially made to any required shape or size at a somewhat higher cost. Certain qualities of water are, however, liable to attack the zinc used in galvanising. Lead-lined cisterns can also be made to fit almost any position; they are formed of deal, usually dovetailed at the angles, and may be lined in position. For small cisterns, the bottom and sides may be formed out of a single piece of lead, the angle pieces cut out and the sides and ends turned up and well lapped, and afterwards soldered. For larger cisterns, the sides and ends are first fixed, and the bottom is afterwards inserted, and all the joints are soldered or burnt. The upper edge of the sides and ends are turned down over the woodwork.

Lead-lined Sinks. These are prepared in the same way, and may be lined like a small cistern from a single piece of 7-lb. lead, with soldered angles; but it is usual to line the sides first, and to use a heavier quality of lead for the bottom, 8-lb. or even heavier if required to stand hard wear. The bottom of the sink should be *dished*—that is, slightly hollowed, and the outlet for the waste is arranged at the deepest part of the sinking.

Lead safes are required in many positions; where they are little liable to interference they are sometimes formed simply as a tray of lead, formed of a single sheet, the edges turned up for about 3 in. or 4 in. and the angles folded over [20]. Such a lead safe may be used inside an enclosure to a bath and even under a cistern, but is easily damaged. A more reliable form of safe is one in which the sides are dressed up against a skirting, or over a rounded or splayed fillet, and then copper-nailed. It is important that the sole or floor of such area should be large enough to take any drippings or overflow from the apparatus under which it is fixed, and the floor should, if possible, have a slight fall towards the outlet from the safe, which should be taken through the wall to discharge into the open air. The end of such a pipe may be fitted with a small lid hung vertically and hinged to a brass sleeve soldered to the end of the lead pipe. This allows any water to issue from the pipe, but prevents air passing up it.

General Arrangements of Water Supply. The connection to the company's mains is made by a ferrule or union, and this work is done by the company's own workmen. A pipe is taken to a point within the building, and should be laid in a trench not less than 2 ft. deep as a protection against freezing. It is taken up inside the building to a cistern, where one is employed, and is termed the *rising main.* At a point near the connection to the main a stop-valve is inserted to shut off the water, and a draw-off tap should be placed not far above this point, as a means of emptying the length of pipe from this point to the cistern; the tap to the scullery sink is very usually serviceable for this purpose. The upper end of the pipe is turned over the edge of the cistern and fitted with a ball-valve. If the rising main is of lead it is joined to the ball valve by a copper bit or blown joint; and if the pipe is of iron, with a screw union. The *ball valve* [21] is one in which the valve is opened and closed by means of a plug attached to a long arm, at the extremity of which is fixed a ball, usually of copper. When unsupported, this arm falls by its own weight, opens the valve, and allows water to pass. When the level of the water in the cistern reaches the ball it floats on the surface, and, as the water rises, is lifted and gradually closes the valve. It must be fixed at such a level that the valve is completely closed when the water-level is an inch or two below the overflow level.

The *overflow* is an essential in every cistern, and provides for carrying off the water should any accident prevent the ball valve from completely shutting off the supply. Were there no such overflow the cistern might continue to fill till it overflowed round the edges. The overflow must be of sufficient size to carry off the water when delivered by the rising main at full bore, and as this water is delivered under considerable pressure the diameter of the overflow pipe should be greater than that of the rising main. The best form of overflow consists of a strong lead pipe standing in the cistern and taken through the bottom or side. The upper end is enlarged to the form known as a *trumpet mouth* to facilitate the flow of water into the pipe [23]. The lower end is taken through the wall to discharge into the open air, and should do so at some point where the discharge will be at once noticed, and attention will then be drawn to the fact that the ball valve is out of order. An ordinary method of making an overflow is to drill a hole in the side of the cistern above the highest

water-level and to conduct an overflow pipe from this. Where this is done the opening should be large or it may fail to carry off the water rapidly enough, as it cannot flow full bore till the water has risen above the level of the top of the pipe.

The cistern should stand in a lead tray or safe, already described, and should be provided with a cover, and, if in an exposed position, may be cased in with boarding, and silicate cotton or other non-conducting material may be packed round it as a precaution against freezing.

Services. The pipes connecting the cistern with the various fittings and taps are termed *service pipes*, or, shortly, *services*. The size of the pipes used will depend on the number and character of the fittings to be supplied.

The service to all such fittings as water-closets, urinals, and housemaid's slop sinks should be kept quite distinct from the service to ordinary fittings, and it is most desirable that there should be an entirely independent cistern to supply this class of fittings only.

Where the cistern is fixed at the top of a lofty building it may prove desirable to provide additional cisterns at an intermediate level, or at more than one, so as to reduce the pressure on the fittings.

Connecting the Service to the Cistern. The service pipe must be brought through the side or bottom of the cistern, which is perforated for this purpose. This is done by soldering the lead service pipe to a brass or gun-metal *union* [**24**], which is provided with a double screw and nuts. This is passed through the perforation and the nuts are screwed up tight against the metal of the cistern, one from inside and the other from outside. Where iron pipes are used, the connection between the pipe and union is made with a screw joint. If the connection is made through the bottom of the cistern, the pipe should stand up inside for about 2 in., to prevent any sediment collected in the bottom of the cistern being drawn into the pipe. If necessary, more than one service may be taken from the same cistern.

Every service should have, as close to the cistern as possible, a *stop-valve* inserted [**24**], but this should be, if possible, in an easily accessible position. This valve allows of a tap being taken off for repair without the necessity of emptying the cistern. Where a service is divided into two main branches it is advantageous to place a similar valve on each branch.

Services are taken by the most convenient route to the various fittings. Care should be taken to see, as far as possible, that at no point is there any dip in the pipe, or even any absolutely level length of pipe, otherwise it is impossible to empty the pipe completely. Joints in service pipes, whether for uniting two pipes in the same direction or a main pipe and a branch, are made with wiped joints.

Connecting Pipes to Taps. *Draw-off taps*, or *bib-cocks* [**25**], to be used with lead service pipes are provided with a spigot end—generally slightly tapered—inserted into the end of the lead pipe, which is correspondingly opened, and a copper bit joint is made; the pipe may be screwed to this spigot or a connection made by means of a union and nuts. Where a tap is fixed at the end of a service pipe a short branch should be wiped on and the service pipe continued for about 2 ft. and turned up and closed and soldered over. This end will be filled with air, and form an air cushion, which will take up any shock due to the sudden check of the flow of water when the tap is closed down.

Taps are made in a great variety of patterns for different purposes and of different sizes to suit various fittings, and the sizes of the service pipes must be adapted to those of the taps they serve. Taps are usually in brass or gun-metal, and may be electroplated or silver-plated.

The common *bib-cock* is arranged to open and close the aperture in the tap by use of a handle turned in a horizontal direction, a quarter turn, when it is shut, being sufficient to open it full. This is a useful tap for low pressure. For work at higher pressure screw-down valves are suitable; these may be *quick-turn*, which are opened and closed by a partial revolution of the handle, but the ordinary screw-down valve requires several turns. Either of these forms, of which there are many varieties, when turned on, continues to run till turned off again, and this may lead to waste of water. There are various forms of spring action valves which are self-closing, but these are apt to get out of order, and require to be held down as long as water is required to flow.

Wastes. All fittings which are required to hold water temporarily, and at the same time to discharge it readily when required, must be provided with an outlet suitably placed for this purpose. This applies to all forms of sinks, lavatories, and baths, and in all such fittings the outlet is arranged in the bottom of the fitting, which should be formed so that all water is drained towards the outlet, which must be at the lowest point. In some lavatory basins the outlet is included with the basin as supplied, but when not included a brass outlet must be provided, and this is bedded in red lead and fixed to earthenware lavatories with a brass *union and fly nut* [**27**], and is provided with a stopper attached to a chain or raised by means of a rod; there may also be a fixed or movable cobweb grating to prevent any large substance entering the waste. The lead waste pipe is wiped on to a brass spigot and attached with a nut to the screwed end of the outlet, and a lead trap is inserted in the waste pipe near the basin.

The end of the waste pipe beyond the trap is taken through the wall to deliver into or over a gully if at the ground-floor level, or into a rain-water head if at a higher level. The outlets from stoneware sinks are similarly treated. In the case of lead-lined sinks the brass outlet is soldered in, but in other respects it is similar. Where it is necessary to carry a long lead waste pipe down an external wall that receives the discharge from a washing-up sink, and which is liable, therefore, to be affected by the frequent use of hot water, a special *expansion joint* is used.

This joint is formed by opening out the head of the lower pipe evenly for a depth of about 7 in. by driving in a mandrel with a rounded end [**28**]. The foot of the upper pipe is also slightly opened, so that it just fits into the socket, and a rubber ring is fitted over the end of this pipe before it is inserted, and, when fixed, the end of the upper pipe should be about 1 in. above the shoulder of the socket. The upper edge of the socket may be protected by a lead cap sliding on the pipe.

Overflows. Both sinks and lavatory basins should have overflows, which should be easily accessible for cleansing. One of the best forms is the *standing waste* and overflow combined [**29**], which entails no additional plumbing, but if a separate overflow is provided, it must be connected to the waste pipe between the basin and the trap.

Traps. *Traps* are made in various forms for both sinks and lavatories. They are usually of cast lead, and have a brass *cleaning eye* below them fitted with a screwed stopper; in many forms the upper end of the trap is trumpet shaped, so that the bore of the trap is slightly reduced. Any trap employed should be self-cleansing, and should not tend to syphon out; but where the pipe beyond the trap is long this cannot be prevented, except by the provision of an anti-syphon pipe, taken from near the outlet of the trap to the open air.

Baths. Baths are sometimes made provided with a trapped outlet as part of the fitting; but when there is no such outlet provided, a brass outlet and plug and washer must be attached to the opening in the bath provided for it, and fitted with a trap and waste. An overflow should also be provided, and may be a standing waste, as described for a lavatory basin, or if a separate overflow waste is formed in the bath, this must be connected to the waste between the bath and the trap.

Closets. Water-closets are manufactured in a great variety of forms, and it is impossible to discuss the merits of the various types in detail in this article. The following points should, however, be attended to in selecting an apparatus. The pan should have the back nearly or quite vertical, as being less likely to be soiled, and the water area in the pan should also be large; the trap should be completely cleaned out by a single discharge of the flush.

The principal types of closets now in use are the *valve closet* [**35**] and the *pedestal* or *wash-down* closet, including *syphonic* action closets [**31**]; the wash-out closet and the old form of hopper closet are undesirable forms to use, as they readily become foul.

The plumbing work connected with water closets consists in taking a water supply to the closet and in connecting up the outlet to the drain, and the latter will be considered first. The pan and trap are sometimes made in one piece, sometimes in two separate pieces. In the former case the whole apparatus is in earthenware; in the latter the trap may be either of lead or of earthenware.

Earthenware traps, if used on a ground floor, and firmly bedded, may be connected to the earthenware drain directly with a Portland cement joint similar to an ordinary drain joint. On an upper floor this is impossible. Messrs. Doulton have a patent joint which they term *metallo-ceramic*, and which allows of a lead soil pipe being soldered directly to the spigot end of the earthenware trap. This joint can be used only with their closets. Where earthenware traps are to be connected to lead branches the trap may be provided with a flanged outlet, the lead pipe having a similar flange, and the two are secured together with clips and screws with a packing of indiarubber between them [**33**]. A simple spigot end may be formed to the trap; in this case a socket is formed on the end of the lead branch, and a joint is made with elastic cement. A little yarn is first dipped into the hot cement and caulked into the joint, and the cement afterwards melted into it with a blowpipe. Where such a trap is connected to the branch of an iron soil pipe, the joint between the spigot and the socket of the iron pipe may be made in Portland cement. But whenever such apparatus is to be connected with a lead pipe it is preferable to use a lead trap, and to make an ordinary wiped joint between the trap and pipe. If the soil pipe is of iron, the end of the lead trap has a sleeve or ferrule of brass or copper soldered to it, and this is inserted into the socket of the iron pipe, and the joint made with blue lead.

Soil Pipes. The branch from the water-closet is wiped to the external soil pipe, and must be connected to it by an easy bend having a good fall throughout [**31**]. Several such branches from different closets may be connected to the same vertical soil pipe, and this should be carried up to form a ventilating pipe to the drainage system [see page 782]. The method of jointing and supporting this pipe has been already described; it is connected to the earthenware drain as follows: The lower end has a sleeve of brass or copper with a flange soldered to it, and this is inserted into the socket of the earthenware pipe, and made good in Portland cement [**33**]. Soil pipes may also be made in heavy cast iron with sockets cast on at the sides to receive the necessary branches [**34**]; the joints are made with blue lead, as described on page 736.

Anti-syphonage Pipes. Where several closets discharge into the same soil pipe, there is a danger that the discharge of one closet may, by the sudden reduction of the atmospheric pressure in the pipe, syphon out the water from one or more of the other traps connected with it. To avoid this a smaller pipe, generally 2 in., is connected with the upper part of each trap on the side next the soil pipe, and taken through the wall and wiped to a similar vertical pipe. This may be left open at the top and carried up to the same height as other ventilating pipes, but it is more usually connected with the soil pipe beside which it occurs at a point about 2 ft. above the highest connection it receives from a water-closet [**31**].

Water Supply to Closets. In the case of valve closets, unless specially required by the water company, it is not necessary to employ a water-waste preventing cistern.

Water-waste preventing cisterns are manufactured in great variety; such a small cistern contains two gallons, or, in some cases, three gallons of water and water is laid on to them in the ordinary way by a small service pipe, usually ½ in., and a ball valve [**32**]. They are discharged by pulling down a handle, when the contents are at once and completely emptied; and when once discharged they must be allowed time to refill. In selecting such a cistern it is well to employ one fitted so that it may refill fairly rapidly, say, within two minutes; it is desirable also to select a pattern that has no mechanical parts that will easily get out of order, and one that is not extremely noisy when discharged.

The size of the outlet is regulated by the distance the cistern is fixed above the apparatus to be supplied, and should ensure a 3-gallon flush being passed into the apparatus within five seconds. The following give the suitable sizes of service pipes for various heights: under 3 ft. head service pipe should be 2½ in.; with head of 5 ft., 2 in. service; 10 ft. head, 1½ in. service; 15 ft. head, 1¼ in. service; 20 ft. head, 1 in. service. The service pipe from the cistern to the apparatus should descend as directly as possible, and any bends used must be easy bends. The connection to the cistern is usually made with a union; that with the apparatus with a rubber cone [**31**], which is secured to the end of the pipe, and also the earthenware inlet formed on the apparatus by wire or stout twine securely twisted round outside the cone; the inlet on the apparatus is connected directly with a flushing rim, and the water circulates all round the rim, and is discharged from a continuous opening at its lower edge, so as to distribute the water over the whole surface of the apparatus.

INTERNAL PLUMBING *concluded; followed by* FOUNDRY AND SMITH WORK

SQUARES ON SIDES OF TRIANGLES

Ratio and Area. Areas of Similar Figures. Similar Figures on Sides of a Right-angled Triangle. Ptolemy's Theorem

continued from page 5473

By HERBERT J. ALLPORT, M.A.

RATIO AND AREA

Proposition 63. Theorem

The ratio of the areas of two triangles of the same altitude is equal to the ratio of their bases.

For, by Prop. 31,

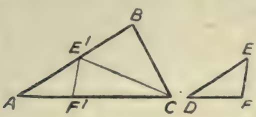
The area of a $\Delta = \frac{1}{2}$ base $\times$ altitude.

Hence, if the bases of the Δs are a and a', and h is the altitude,

Area of first Δ : area of second $:: \frac{1}{2} ah : \frac{1}{2} a'h$,
$:: a : a'$.

Proposition 64. Theorem

If two triangles have one angle of the one equal to one angle of the other, the ratio of their areas is equal to the ratio of the products of the sides containing the angles.



Let Δs ABC, DEF have $\angle A = \angle D$.

It is required to prove that

$\Delta ABC : \Delta DEF :: AB \,.\, AC : DE \,.\, DF$.

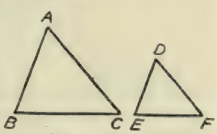
Proof. Place the ΔDEF on the ΔABC so that D falls on A, DE along AB, and DF along AC. Let E′, F′ be the new positions of E, F. Join CE′. Then

$$\frac{\Delta ABC}{\Delta DEF} = \frac{\Delta ABC}{\Delta AE'F'} = \frac{\Delta ABC}{\Delta ACE'} \times \frac{\Delta ACE'}{\Delta AE'F'}$$

$$= \frac{AB}{AE'} \times \frac{AC}{AF'} \text{ (Prop. 63)} = \frac{AB.AC}{DE.DF}.$$

Proposition 65. Theorem

The ratio of the areas of similar triangles is equal to the ratio of the squares on their corresponding sides.



Let ABC, DEF be similar Δs.

It is required to prove that

$\Delta ABC : \Delta DEF :: AB^2 : DE^2$.

The $\angle A = \angle D$.

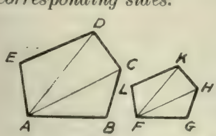
$$\therefore \frac{\Delta ABC}{\Delta DEF} = \frac{AB.AC}{DE.DF} \text{ (Prop. 64).}$$

But, since the Δs are similar, $\frac{AB}{DE} = \frac{AC}{DF}$.

$$\therefore \frac{\Delta ABC}{\Delta DEF} = \frac{AB \,.\, AB}{DE \,.\, DE} = \frac{AB^2}{DE^2}.$$

Proposition 66. Theorem

The ratio of the areas of similar rectilineal figures is equal to the ratio of the squares on their corresponding sides.



Let ABCDE, FGHKL be similar figures, in which AB and FG are corresponding sides.

It is required to prove that

Fig. ABCDE : fig. FGHKL $:: AB^2 : FG^2$.

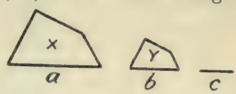
Proof. Since the figures are similar, the Δs ABC, ACD, ADE are respectively similar to the Δs FGH, FHK, FKL (*Prop.* 62, *Cor.*).

$\therefore \Delta ABC : \Delta FGH :: AB^2 : FG^2$ (*Prop.* 65).
$\Delta ACD : \Delta FHK :: AC^2 : FH^2$
$\Delta ADE : \Delta FKL :: AD^2 : FK^2$.

But, since the figures are similar, the ratios AB : FG, AC : FH, and AD : FK are all equal (*Prop.* 62). Therefore, by addition,

Fig. ABCDE : fig. FGHKL $:: AB^2 : FG^2$.

Corollary 1. Let a, b, c be three straight lines in proportion.



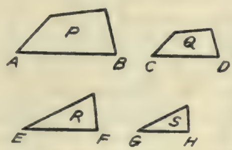
Then, $a : b :: b : c$,
so that, $b^2 = ac$.

Now, let similar figures X and Y be drawn on a b as corresponding sides.

$\therefore$ Fig. X : fig. Y $:: a^2 : b^2, :: a^2 : ac, :: a : c$.

Hence, *if three straight lines are proportionals, and similar figures are drawn on the first and second as corresponding sides, then,*

Fig. on *first* : fig. on *second* $::$ *first* : *third*.



Corollary 2. Let AB : CD :: EF : GH. On AB, CD as corresponding sides, draw similar figures P, Q; and, on EF, GH as corresponding sides, draw similar figures R, S.

Then P : Q $:: AB^2 : CD^2$,
and R : S $:: EF^2 : GH^2$.

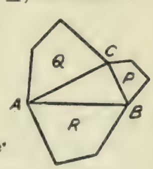
But, since the lines are proportionals,

$AB^2 : CD^2 :: EF^2 : GH^2$.
$\therefore P : Q :: R : S$.

Hence, *if four straight lines are proportionals, and a pair of similar figures is drawn on the first and second as corresponding sides, and also a pair on the third and fourth, these figures are proportionals.*

Proposition 67. Theorem

The rectilineal figure described on the hypotenuse of a right-angled triangle is equal to the sum of the two similar and similarly described figures on the other two sides.



Let ABC be a right-angled Δ, in which C is the right angle. On AB, BC, CA draw similar figures R, P, Q, having the sides of the Δ for corresponding sides.

It is required to prove that

Fig. P + fig. Q = fig. R.

Proof. Since P and R are similar

$$\therefore \frac{P}{R} = \frac{BC^2}{AB^2} \text{ (Prop. 66),}$$

Similarly, $\dfrac{Q}{R} = \dfrac{CA^2}{AB^2}$.

$$\therefore \frac{P + Q}{R} = \frac{BC^2 + CA^2}{AB^2}.$$

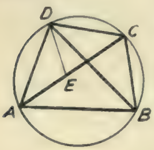
But, since ABC is a right-angled Δ,

$$\therefore BC^2 + CA^2 = AB^2.$$

$\therefore$ fig. P + fig. Q = fig. R.

Proposition 68. Theorem
Ptolemy's Theorem

The rectangle contained by the diagonals of a quadrilateral inscribed in a circle is equal to the sum of the two rectangles contained by its opposite sides.



Let ABCD be a cyclic quadrilateral.

It is required to prove that rect. AC . BD = rect. AB . CD + rect. BC . AD.

Proof. Make the $\angle$ADE = $\angle$BDC.

The $\angle$DAE = $\angle$DBC in the same segment.

$\therefore$ Δs ADE, BDC are similar.

$\therefore$ AD : AE = BD : BC,

so that rect. AD . BC = rect. BD . AE.

Again, since $\angle$ ADE was made equal to $\angle$BDC, the whole $\angle$ADB = the whole $\angle$EDC. And $\angle$ABD = $\angle$ECD, in the same segment.

$\therefore$ Δs ADB, EDC are similar.

$\therefore$ HB : BD = EC : CD,

so that rect. AB . CD = rect. BD . EC.

$\therefore$ rect. AB . CD + rect. AD . BC
= rect. BD . AE + rect. BD . EC
= rect. BD (AE + EC) = rect. BD . AC.

Proposition 69. Theorem

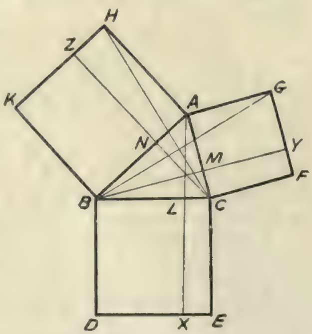
In any triangle, the square on the side opposite an acute angle is less than the sum of the squares on the sides containing that angle by twice the rectangle contained by either of these sides and the projection of the other on it.

Let ABC be a Δ in which $\angle$ A is acute. Draw AL, BM, CN $\perp$ to BC, CA, AB. Then AN is the projection of AC on AB. On BC, CA, AB draw the squares BCED, CAGF, ABKH.

It is required to prove that

$$BC^2 = AB^2 + AC^2 - 2 \text{ rect. } AB . AN.$$

Proof. Produce AL, BM, CN to meet the opposite side of the squares in X, Y, Z.



Then, since CN and AH are each $\perp$ to AB,

$\therefore$ ANZH is a rectangle.

Similarly, AGYM is a rectangle.

Again,

$\angle$CAH = $\angle$BAC + a rt. $\angle$,

and $\angle$BAG = $\angle$BAC + a rt. $\angle$.

$\therefore$ $\angle$CAH = $\angle$BAG.

$\therefore$ in Δs CAH, BAG, the sides CA, AH are equal to GA, AB, and $\angle$CAH = $\angle$BAG.

$\therefore$ the Δs are equal.

But ΔCAH = $\frac{1}{2}$ rect. ANZH (*Prop.* 31),

and ΔBAG = $\frac{1}{2}$ rect. AGYM.

$\therefore$ rect. ANZH = rect. AGYM.

Similarly, rect. BNZK = rect. BLXD,

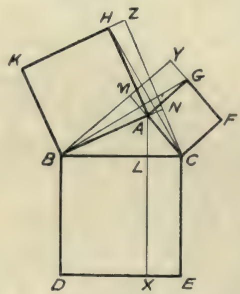
and rect. CMYF = rect. CLXE.

$\therefore$ fig. BE = fig. BH + fig. CG − figs. HN, GM;

that is, $BC^2 = AB^2 + AC^2 - 2$ rect. AH . AN.
$= AB^2 + AC^2 - 2$ AB . AN.

Proposition 70. Theorem

In an obtuse-angled triangle, the square on the side opposite the obtuse angle is greater than the sum of the squares on the sides containing that angle by twice the rectangle contained by either of these sides and the projection of the other on it.



Let ABC be a Δ in which $\angle$ A is obtuse.

Using the same construction as in *Prop.* 69, it is required to prove that

$$BC^2 = AB^2 + AC^2 + 2 \text{ rect. } AB . AN.$$

Proof. As before

rect. ANZH = rect. AGYM.
rect. BNZK = rect. BLXD.
rect. CMYF = rect. CLXE.

$\therefore$ fig. BE = fig. BZ + fig. CY,
= fig. BAHK + rect. ANZH
+ fig. CAGF + rect. AGYM;

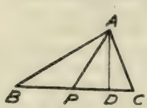
i.e., $BC^2 = AB^2 + BC^2 + 2$ rect. ANZH,
$= AB^2 + BC^2 + 2$ AB . AN.

DEFINITION. The straight line which joins any vertex of a triangle to the middle point of the opposite side is called a *median* of the triangle.

Proposition 71. Theorem

In any triangle, the sum of the squares on two sides is equal to twice the square on half the third side together with twice the square on the median bisecting the third side.

Let ABC be a Δ, and AP a median.



It is required to prove that

$$AB^2 + AC^2 = 2\,BP^2 + 2\,PA^2.$$

Proof. Draw AD $\perp$ to BC. Then, from the obtuse-angled ΔABP,

$AB^2 = BP^2 + PA^2 + 2$ BP . PD (*Prop.* 70),

and, from the acute-angled ΔACP,

$AC^2 = CP^2 + PA^2 - 2$ CP . PD (*Prop.* 69).

$\therefore$ since BP = CP, we get, by addition,

$$AB^2 + AC^2 = 2\,BP^2 + 2\,PA^2.$$

Continued

TEXTILE DYEING

The Principal Textile Fibres from the Dyer's Point of View. Widely Different Natures of Cotton, Wool, and Silk

By HERBERT ROBSON

FORMERLY many manuals for dyers were simply recipe books. The practical dyer recorded his results from day to day, together with patterns of the actual work. A recipe, *together with the pattern*, is still interesting and useful, but as a rule the dyer is now able to work without specific instructions. If he is given a direct cotton colour, a sulphur colour, or a basic dyestuff, for instance, he knows that a general method is applicable in each case, and it is a simple matter for him to dye to shade. Recipes without patterns are therefore of little interest to him. Where one is given in this course it is merely as an illustration, and the writer has in every case seen the pattern.

As a rule, the quantities are given in percentages. For instance, 2½ per cent. toluylene dark blue, 5 per cent. soda ash, 20 per cent. Glauber's salt, means that to every 100 lb. weight of goods 2½ lb. toluylene dark blue, 5 lb. soda ash, and 20 lb. Glauber's salt have been added to the dye-bath, which is ordinarily made with from 200 to 220 gallons of water.

The Textile Fibres. Textile fibres have been classed in four categories, as animal, vegetable, mineral, and artificial, but from the point of view of the dyer it is more practical to divide them simply into animal and vegetable fibres. The types of these classes are cotton and wool, by far the most important textiles, and the differences of their behaviour towards reagents are characteristic of the animal and vegetable fibres generally, and govern their treatment in the dye-house. Wool is destroyed by moderately concentrated alkalis but resistant to dilute acids. Cotton is not injured by moderately concentrated solutions of alkalis, but is carbonised by acids, and even rather dilute acids have an injurious effect upon it. The two fibres behave very differently to tannic acid. Cotton has a strong affinity for it, which fact is taken much advantage of in dyeing, whereas wool can be made to absorb only a trifling percentage of it. On the other hand, wool has a strong affinity for many classes of dyes; it has a powerful decomposing effect upon metallic mordants, and readily retains the oxides. Cotton is very inert, and it is comparatively recently that a class of artificial dyestuffs has been discovered which will dye it without the intervention of mordants. Wool, therefore, with certain limitations, is easier to dye than cotton. Silk in some ways is in a class by itself; it may be looked upon as animalised vegetable fibre, but in its general behaviour to reagents it strongly resembles wool.

Vegetable Fibres. Vegetable fibres are divided into two classes—seed hairs and bast fibres. Cotton is the only textile of importance in the first category, although many attempts have been made to utilise the fibrous growth on other seeds. The bast fibres are obtained from the stem of plants, as in the case of flax and jute, or from the leaves, as in the case of ramie. In cotton each fibre is a single cell, whereas bast is composed of bundles of cells. The differences between the vegetable fibres are mainly of structure, and concern those charged with the preparative processes rather than the dyer, who nevertheless is obliged to modify his treatment more or less according to the particular fibre with which he is dealing. The principal constituent of all vegetable fibre is cellulose. Cotton is almost pure cellulose, linen somewhat less pure, and all the other fibres have much more of what, from the point of view of the dyer, may be looked upon as natural impurities.

Cotton. Lancashire spinners and manufacturers make a broad but practical division of cotton into four classes, according to the length and diameter of the fibre. Sea Island is the finest and longest, Egyptian comes next, American is the mainstay of commerce and the typical cotton, and Surat, or Indian, is a low-grade, short-fibred cotton which nevertheless finds its uses.

These cottons are the down enveloping the seed of various species of Gossypium, and on the plantations the fibre is picked by hand and ginned by machinery. Both these operations have an effect on the subsequent dyeing operations. If the cotton is not ripe it will dye unevenly, and imperfect ginning will cause it to be full of dust, seed particles, and leaf. Leaf and seed particles are very tenacious, and may appear in the yarn or even in the cloth as black spots. In this case the oil in the seed will give trouble, and cause spotty dyeing.

Nature of Cotton. Apart from these impurities, which should not be present, cotton is composed of cellulose, water, and about 5 per cent. of constituent impurities, consisting of pectic acid, colouring matter, wax, and fatty and albuminous matters. The amount of colouring matter varies greatly; it is almost absent in Sea Island and white Egyptian, and largest in brown Egyptian. In this cotton and in the tawny fibres of India it has to be taken into account by the dyer if he is dealing with unbleached goods. The wax, together with a very delicate cuticle which is not cellulose, serve as a sort of waterproofing to the fibre. This is the reason why the dyer dealing with unbleached goods is obliged to scour or wet out the cotton before entering it into the dye bath. The fatty matter in the fibre is identical with the oil in the seed, and also requires to be removed. The influence of this wax and fat can be noted if greycloth is steeped in cold water; it will be found that a considerable time elapses before it is wetted out. The pectic acid is an amorphous substance resembling a gum, insoluble in cold water, but readily soluble in hot water.

Bleaching, therefore, in which process alkalis are used and form soaps with the fatty matters, removes these impurities and leaves almost pure cellulose, the albuminous matter being in such small quantity as to be negligible. Cellulose is a carbohydrate—that is, a substance which contains carbon together with hydrogen and oxygen in the proportions in which they occur in water. Its formula is $C_6H_{10}O_5$, so that it is closely allied to starch and sugars. It is colourless, and has neither taste nor smell. Its specific gravity is about 1·5. It stands heat until about 290° F.; at this temperature it begins to turn brown and decompose.

It is absolutely insoluble in the ordinary solvents—water, alcohol, and ether, etc., and is not acted upon by them in any way.

This general inertness, although it is the cause of the want of affinity for colouring matter, is of valuable assistance to the dyer, inasmuch as it enables cotton to stand all the various processes through which he has to put it. Cellulose, moreover, is hygroscopic, and the moisture taken up from the air renders the fibre soft and elastic.

Mercerised Cotton. John Mercer, a Lancashire calico-printer, in 1844 discovered that caustic alkali solutions, much more concentrated than are used in bleaching, had effects upon vegetable fibre of great technical interest. In 1850 he brought out a patent which described the "new properties" given to vegetable fibres by treatment with caustic alkalis and other reagents. The practical interest of his discovery has been almost narrowed down to cotton as the treated fibre and caustic soda as the reagent employed.

When cotton is treated with caustic soda solution of about 60° Tw., neutralised with acid and washed, the fibre shrinks and acquires greater strength, and also greatly augmented powers of taking up colour in dyeing and printing. These two points were the object of his patent, but he showed, at the Exhibition of 1851, samples of cotton cloth craped by printing the goods in patterns or stripes with the lye, allowing it to dry, and steaming the fabric. The printed places contract and remain smooth, dragging the unprinted places with them, which thus become crinkled.

In Mercer's time the cost of caustic soda was prohibitive and mercerising had no commercial importance until, in 1885, the French firm of Depoully reinvented craping by means of caustic soda, introducing a variety of novel applications, and for the first time made a commercial success of Mercer's discovery. In 1890, Lowe, a Manchester chemist, patented the application of tension to prevent shrinking while the material is impregnated with the alkali, and claimed that the material acquired "a better appearance or finish, and at the same time an increased tensile strength, and an augmented affinity for dyestuffs." A few years later, Thomas & Prevost, a firm of Crefeld dyers, were engaged in dyeing silk-cotton mixtures. Wishing to increase the affinity of cotton for dye they had recourse to mercerisation, and to prevent the cotton contracting they washed it in a state of tension. They were using the finest staples, and they found that these Sea Island and white Egyptian yarns took a magnificent silky gloss. This they patented in 1896, but in view of Lowe's priority the patents were afterwards annulled.

Lustre-mercerisation. The chief interest in the process to-day lies in this lustre-mercerisation, by which cotton is given the appearance of silk, and it is necessary for the dyer to understand the properties the cotton has acquired, and the new conditions under which he must work. Generally speaking, all classes of dyestuffs ordinarily used for cotton are available, but 25 to 35 per cent. less dyestuff is required to dye to the same depth of shade, and the colour goes on much more quickly than in the case of unmercerised cotton. This tends to uneven dyeing, and the remedy is long baths—this is, with plenty of water—the employment of colours which exhaust slowly, a decreased addition to the bath of Glauber's salt, and more soda, soap, or other ingredients which retard the action of the colouring matter. In the case of dark shades, the bath, of course, must not be too long. Another point the dyer must take into consideration is that the manner of dyeing must not injure the lustre of the goods. For this reason the direct cotton dyes are largely employed on mercerised material. In union goods, when mercerised and dyed cotton is used, it is more liable to bleed on to the wool than ordinary cotton, and a class of dyestuffs has been introduced to remedy this.

Apart from lustring, Mercer's original idea of using caustic soda to economise dyestuff has found a limited use. It was quickly discovered that even comparatively weak lyes, not capable of contracting the cloth, would save dyestuff, and that certain wool dyes could be used on mercerised cotton. With both the natural and the artificial colours there is always an economy of dyestuff, and sometimes a simplification of the process, as in the case of several basic dyes, which may be used without a mordant. It is very necessary, therefore, that the dyer should study mercerised cotton from every point of view, and consult exhaustive treatises on the subject.

Linen. Flax or linen fibre is obtained from several species of the genus Linum, but especially from the flax plant, *Linum usitatissimum*, cultivated in many parts of Europe, and notably in the North of Ireland. To-day nine-tenths of the Continental supply is grown in Russia. Being a bast fibre, it is much more difficult to prepare for the spinner than cotton, and the most important operation is retting, in which process the flax is steeped in cold or hot water to remove the adhesive substances which bind the fibres to each other and to the woody portion of the stem. The method of retting is of importance to the dyer, inasmuch as it influences the colour of the product as he receives it. The fibre should then be snowy white and lustrous.

Its chemical composition is very similar to cotton, but it contains more pectic acid and other impurities, from which it is freed on bleaching, as in the case of cotton. It absorbs about the same amount of moisture, but is a better conductor of heat, and is less elastic. It is more affected by caustic alkalis and bleaching agents, and although, as it is cellulose, the methods employed are much the same as in cotton dyeing, it is more difficult to deal with. Even unbleached linen, however, can be readily dyed with substantive cotton colours by boiling twice with 5 per cent. soda, and rinsing well. It has some affinity for the basic dyes, as it contains a small amount of tannin. The fibre, as it comes to the dyer, contains woody and waxy impurities, varying according to the nature and thoroughness of the preparatory operations, and also cellulose, converted by the excessive percentage of pectic acid—as compared with cotton—into pecto-cellulose.

This, together with the physical structure of the fibre, explains the extra difficulty. The introduction of direct cotton dyestuffs, however, greatly simplified the dyeing of linen, and they are very largely employed.

Jute. Jute is the bast fibre of various species of Corchorus, and our supply comes principally from Bengal. The preparation of the fibre from the plant is similar to the processes used in the case of flax, but simpler, and the product is freer from woody impurities. The raw fibre consists of bundles of stiff fibrils, with irregular walls and a large central opening. The physical structure is the main difficulty of the dyer, and the dyed jute often shows an absolute untouched centre if the fibre is cut across. This is of little moment, however, in the ordinary uses of jute.

According to the great authorities on cellulose, Cross and Bevan, jute is not cellulose, but bastose, a compound of cellulose with lignine. This bastose behaves very similarly to tannin-mordanted cotton, and jute can be dyed direct with basic dyes. Jute, in fact, according to Hummel, is cellulose, a portion of which has become more or less changed into a tannin-like substance. Alkalis attack jute, resolving it into cellulose and soluble bodies allied to tannins, and acids readily disintegrate it. This must be taken into account by the bleacher and dyer. It is best bleached by the successive action of permanganate of potash and sulphurous acid, but the bleach does not last. Treated as in cotton bleaching, but with weaker lyes, an imperfect but more stable bleach is obtained. The dyer has to put his best work in when the jute fibre is intended for use as a binding thread in carpet weaving, or for cheap classes of upholstery.

Hemp. A very large number of bast fibres come on to the market under the name of hemp. The ordinary hemp, largely grown in Russia and India, is the fibre of *Cannabis sativa.* It is fairly successfully bleached in the Dundee district by special processes, but rapidly turns brown, and is tendered to some extent in the process. It is rarely dyed, but when this is required the substantive dyes are used as for cotton.

Ramie. Technical difficulties in the preparatory processes, and the consequent failure of a steady supply, have prevented this beautiful fibre from taking the place among textiles which it deserves. It is obtained from the stem of a stingless nettle, *Boehmeria nivea*, grown largely in China, whence it has been called China grass. It is also called rhea. It is nearly pure cellulose, and consequently can easily be bleached. It can be dyed like cotton, but care must be taken to preserve the lustre. In light shades, obtained with the substantive colours in lukewarm baths, it has been used for curtain laces and napkins. It has also been used for upholstery.

Minor Vegetable Fibres. Sisal, manilla, coir, and a variety of other fibres, are of little or no interest to the dyer.

Artificial Silk. Several varieties of this are now on the market. The most usual kinds, such as the Chardonnet and Lehner silks, are obtained from solutions of cellulose. They are dyed like ordinary boiled-off silk, but at lower temperatures.

The Animal Fibres. The animal fibres have nothing in common with the vegetable fibres in chemical composition, and are treated in a totally different manner in bleaching and, as a rule, in dyeing. They are nitrogenous substances, and frequently contain sulphur. The great difference between the animal and vegetable fibres is emphasised by a rough test very frequently used by dyers. Take a warp thread of a union cloth and apply a lighted match to it. It burns with a quick, bright flame, and without smell—it is a vegetable fibre. Take a weft thread and hold the light to it. It shrivels up in a brownish bead, and gives off the smell of burning horn—it is an animal fibre. The results, of course, will be reversed if the warp is wool and the weft cotton.

Wool and hair differ only in physical structure. The hair of many animals is used in greater or smaller quantities in the textile industry, but the curly, flexible, and elastic covering of the sheep is the typical textile. It varies not only with the breed and habit of the sheep, but in its age, and even the part of the animal from which it is taken.

Physical Structure of Wool. The physical structure of the fibre is of high importance to the manufacturer and dyer. The external cells are like irregular scales, arranged side by side and overlapping each other. When wool cloth is wet, and especially when exposed to pressure in the presence of soap, the scales interlock and the fabric *felts.* This is the object of milling; in this process a number of wool fibres are brought into close contact and beaten or stamped in soap and water. Each fibre moves more readily in one direction than the other, with the result that the mass of fibres are gradually locked together, and the cloth becomes thicker and denser. This is taken advantage of in the manufacture of many classes of goods, such as flannels, broadcloths, and hat-bodies, but it is a great disadvantage in the dyeing of slubbing and yarns, and the dyer has to guard against it.

Wool is very hygroscopic, much more so than cotton. In warm, dry weather it may contain as much as 12 per cent. of moisture, but in a damp atmosphere it will take up even 50 per cent. When damp, it is not liable to mildew, as are the vegetable fibres. When steeped in hot water the fibre softens and swells and becomes plastic. It may be formed into any shape required, and retains it on cooling. This property is taken advantage of in many textile processes, and is of great importance to the dyer in preventing the wool in mixtures—say, with cotton —from shrinking when washed, and in all wet-finishing processes.

Wool comes on the market as "washed" and "unwashed" according as to whether it has been washed on the sheep's back or not. Wool, "in the grease," as the latter is called, contains a large quantity of impurities, which can be removed by washing and also yoke and suint. Yoke is insoluble in water, but can easily be removed by soap. Suint consists of potassium salts of oleic, stearic, and acetic acids, and as it forms a natural soap with the yoke it helps to remove it.

Chemical Composition of Wool. The chemical composition of the wool fibre itself, when freed from these impurities, closely resembles that of horn. It consists of carbon, hydrogen, oxygen, nitrogen, and sulphur, and the presence of this last element distinguishes it from silk.

The sulphur may cause trouble to the dyer. If the water contain lead, dull shades are produced in a neutral or alkaline bath, but this may be corrected by adding sulphuric acid or in some cases alum. If the wool comes into contact with lead, copper or tin, stains result, owing to the formation of the sulphides of these metals. Mordanting with a tin salt has the same result. If necessary, the sulphur may be almost removed by steeping the wool in milk of lime, washing in water, then in weak sulphuric acid and again in water, repeating the operation several times.

Effects of Acids on Wool. Weak solutions of hydrochloric and sulphuric acids have little effect on the fibre except that they make it feel harsher. They are used in the dye-bath in wool dyeing, and as they are more energetic in their action on cotton they are also used to remove this fibre from rags or shoddy. The usual process is to steep the shoddy in dilute sulphuric acid, squeeze out and dry in a stove at about 225° F. The cotton is carbonised and disintegrated and can be beaten out of the goods.

Concentrated mineral acids destroy wool. Dilute boiling nitric acid is used to take out the colour from goods already dyed, as, for instance in "stripping" garments for re-dyeing or in correcting dye-house mistakes. Sulphurous acid is used as a bleaching agent, as wool would be destroyed in the processes applied to cotton, and must be thoroughly removed by steeping in very weak solutions of chloride of lime and washing well. Otherwise uneven dyeing will result, especially with light colours, which may even be destroyed by the sulphur dioxide retained in the fibre.

An excess of chlorine destroys wool, but when the fibre is submitted to the very slight action of chlorine or of a hypochlorite it is said to be "chlorinated" and has acquired some valuable properties. It has a yellowish tint and a harsher feel, but it has lost most of its power of felting, and therefore the process is used to prevent the shrinking of woollen hosiery and clothing. It has also acquired a greater affinity for colouring matter. This is taken advantage of by the muslin delaine printer very extensively, and also to some extent by the wool dyer, who, for instance, can produce two-colour effects on all wool goods by chloring the warp before weaving, and leaving the weft untreated. The warp then takes up a much deeper colour in the dye-bath.

Effects of Alkalis on Wool. The action of alkalis on wool is very peculiar. While comparatively weak lye at an ordinary temperature disintegrates the fibre more or less rapidly, a short immersion in caustic soda of 82° Tw. at a low temperature, say 50° F., produces an effect analogous to mercerisation. The fibre takes a soft silky feel and scroop, and a greater affinity for colouring matters. The economy of dyestuff effected has never sufficiently been experimented upon, but two-colour effects have been produced in the piece by using "mercerised" and "unmercerised" wool after the manner of chlorinated and untreated fibre. The treated wool is also freed from sulphur to a large extent.

Wool, unlike cotton, has a positive action on metallic mordants, readily decomposing them in hot solutions and retaining their oxides in the fibre. It has also a strong direct attraction for several classes of colouring matters. Its porosity also enables it to be readily treated. This general activity makes the dyeing of wool comparatively easy, but on the other hand it has the drawback of being the frequent cause of uneven dyeing. In most cases the care of the dyer must be to moderate the action of his baths and to regulate his work so that one portion of his goods does not absorb an unfair share of the dye.

Wool from a diseased animal dyes badly, and from the dead sheep much worse still. "Dead fibres" which have been pulled out before the sheep was sheared take the colour badly, and "kemps"—smooth, white, almost scaleless fibres, met with in coarse wools—also take less colour and may produce spotty dyeing. They are usually combed out, however, in the preparatory processes.

Silk. The silk fibre is a continuous thread spun by the silkworm. The ordinary silk of commerce is produced by the mulberry silkworm, *Bombyx mori;* all other descriptions, such as Tussah or Tussore, Eria, Muga, and Atlas, are classed as wild silks.

Raw silk consists of a double fibre cemented with a layer of silk glue. When "boiled off" the fibres are separated, and, losing the yellow of the enveloping glue, are almost white and lustrous. They differ from vegetable fibres and from wool by being devoid of cellular structure. Silk resembles wool in some respects, but it is distinguished from it chemically by the absence of sulphur. Although classed as an animal fibre it also has resemblances to cotton and must be looked upon as animalised vegetable. It is very hygroscopic and will absorb as much as 30 per cent. of moisture without feeling damp. It is very elastic and strong, and has a high lustre.

A very distinctive property is the peculiar crisp rustling sound it emits when it is squeezed in the hand. This is known as the "scroop," and is imitated by chemical means in mercerised cotton. What the French call the *frou-frou* is a valued property in ladies' dress material, and the retention of it has to be carefully ensured in the dyeing operations. Raw silk has no scroop, the property being imparted to it in an acid bath after boiling-off. It can be imparted to it after dyeing, and this is usually done in a bath containing oil and acid. Silk is a bad conductor of electricity, and therefore becomes electrified by friction; this is overcome by keeping the air moist in the rooms where it is worked.

Treatment of Silk. To develop the properties of softness and brilliancy the yarn is submitted to several mechanical processes, and the particular difficulty of the dyer in dealing with it is to retain its mother-of-pearl-like lustre in full. Silk contains, in addition to the fibre, the gum or glue which is soluble in boiling water, small quantities of wax, fat, and resinous matters, a small quantity of ash and water varying with the dampness of the atmosphere. The fibre itself is a compound of carbon, hydrogen, nitrogen, and oxygen. Acids have a more rapid destructive effect on silk than wool, and hot alkalis dissolve it, but not so quickly as wool. Boiling solutions of basic zinc chlorides dissolve silk but do not affect the cotton or wool.

Silk decomposes metallic mordants as readily as wool. Potassium bichromate injures the fibre, and dilute solutions of bleaching powder chlorinate it like wool, increasing its affinity for colouring matter, but to a less extent. It is very easily tendered, even sodium carbonate affecting it in warm solutions, and this is a point that the dyer must bear in mind. It behaves like wool to colouring matters and can be easily dyed direct with several classes of them, and its affinity for the basic dyes is even greater than wool. The terms of the silk dye-house are largely borrowed from the French—*organzine* is warp silk, *trame* is weft; the term *écru* will be explained later.

Continued

ENGINE CYLINDERS & VALVES

The Cylinder and its Parts. The Flywheel. Valve Motions. Lap and Lead. Reversing and Expansion Eccentrics

Group 24
PRIME MOVERS
2

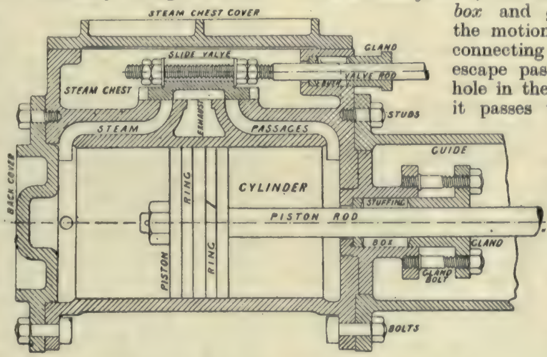
Continued from page 5418

By JOSEPH G. HORNER

ENGINES, apparently very complex, may be reduced to simple elements, which, however, can be more easily studied in the first place in the plain single-cylinder engine. With some notable exceptions, the main function of a steam engine is to convert reciprocating into rotary motion. The reciprocations of the piston in the cylinder are thus converted into the rotary motion of the flywheel. The cylinder and its piston are therefore the first elements in such an engine.

The Cylinder. The cylinder [5] is always of circular section, because this form is more easily produced with accuracy than any other, and because it is the strongest form possible, with the single exception of the sphere. Cylinders are always made by casting, and mostly in iron, because there is no other practicable way of producing the various steam passages and flanges. They are made of ten times greater strength than that which would be required merely to resist the steam pressure, the conditions necessary being absolute rigidity, imperviousness to high pressure steam, and allowance necessary for wear and reboring. Because the piston friction is constant and severe, special grades of metal are used for cylinders, harder and of closer grain than for other parts, such as flywheels, cranks, etc., which have not to endure friction. Or, as in all the larger cylinders, ordinary good stiff metal is used, but the interior, or *bore*, is lined with a tube of harder, more *slippery* metal, generally of a special cast-iron mixture, but in some cases now with compressed steel.

In the early days of the steam engine, and down to about a generation ago, cylinders were made much larger for engines of a given power than they are now. The reason was that steam pressures were very much lower. The first engines used steam of but 3 lb. to 5 lb. pressure to the square inch. Many modern engines use steam at from 180 lb. to 210 lb. to the square inch, and some even more. Such high initial pressures, of course, require a piston area smaller in proportion. And, incidentally, as higher pressures carry higher temperatures, the elastic force of the steam is greater; in other words it can be used more expansively. In the old days boilers were made of cast iron, for wrought iron was very costly, and long after the use of wrought iron became common, pressures of 50 lb. or 60 lb. to the square inch were the maximum. Then came the age of steel, and with boilers made of open-hearth steel the pressures have gone up as just stated, with reduction in cylinder dimensions. At the same time the speeds of rotation have been increased many times. Simultaneously, improved methods of boring, and better fitting of pistons and rods, have ensured absolute steam tightness at these high pressures.



5. CYLINDER OF "JOHN BULL" ENGINE
(E. R. & F. Turner, Ltd., Ipswich)

The Piston and its Rod. Though the piston, also seen in **5**, is movable readily before even moderate steam pressure, it fits nevertheless steam-tight in the cylinder bore. This is effected by a metallic *spring ring*, or rings which are of slender section, the *Ramsbottom* type, in **5**, and being cut through on one side are sufficiently elastic to make close contact with the cylinder bore without offering much resistance to the movement of the piston. The early pistons had no metallic packings, but junk rings of hemp gasket, which were burnt out easily.

The *piston rod*, of steel, passes through the front cover of the cylinder, which is fitted with a *stuffing box* and *gland*, and transmits the motion of the piston to the connecting rod. Steam would escape past the rod unless the hole in the cover through which it passes were packed. This is done either with a hemp gasket, or asbestos, or with metallic packing. To keep the packing in place is the function of the gland, which is screwed down tightly on the packing confined in the stuffing box. The difference in the fitting of the front and back cover may be noticed in **5**.

The Connecting Rod and Parts. The connecting rod is a rod pivoted loosely to the piston rod at one end and to the pin of the crank at the other. At the end where it joins the connecting rod its movements are coerced by the *crosshead*, or *slipper block*, through the body of which the connection is made. The movement of the crosshead is coerced in the same axis as that of the cylinder by means of *guide bars*, *slide bars*, or *slipper bars*, or of a *circular guide*. The connecting rod, therefore, swings in an arc determined by the length of *throw* of the crank, with a radius equal to the distance between the centres of the crosshead pin and the crank pin, receiving at the same time longitudinal movement equal in length to that of the piston stroke.

Obliquity of the Connecting Rod. The angularity of this rod [6], varying from zero on dead centres to maximum angle when the crank pin is at 90° from dead centres, has some results which must be taken notice of, and because of

which the general rule is elaborated that a connecting rod should be as long as is possible in reason.

In the first place, when the piston is at the middle of its stroke, at the point 3 in **6**, the crank pin is not, being either a little ahead, or short of it. This is shown by the diagram where the crank pin, 3′, is not exactly over the centre, *c*, of the crank shaft. In the second place, the rate of revolution is irregular. By dividing the path of the piston into any number of equal parts, 0 to 6, and setting off the length of the connecting rod therefrom to the crank circle, 0′ to 6′, a glance suffices to show that the rate of revolution of the crank pin varies greatly, and changes constantly (compare 0′ to 1′ with 3′ to 4′), and but for the steadying influence of the flywheel, engines would rotate in a more or less jerky fashion, due to the angularity of the rod and partly to the momentary pause in the reciprocation of the piston. Even double engines when coupled do not run with perfect steadiness unless a flywheel is fitted.

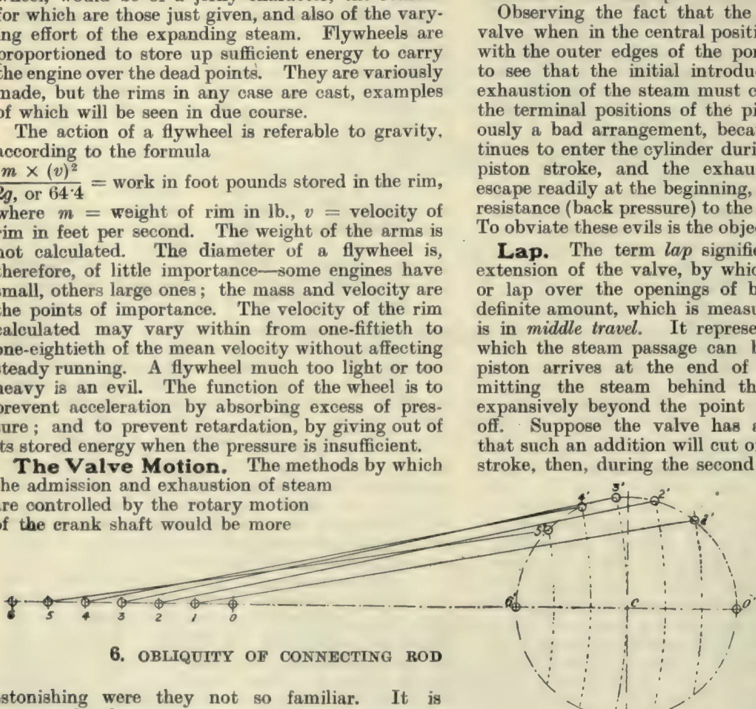
The Flywheel. The flywheel and the crank being keyed on the same crank shaft, the wheel is caused to partake of the rotational movement of the crank. The flywheel is an equaliser of the movements of the piston, which, without the wheel, would be of a jerky character, the reasons for which are those just given, and also of the varying effort of the expanding steam. Flywheels are proportioned to store up sufficient energy to carry the engine over the dead points. They are variously made, but the rims in any case are cast, examples of which will be seen in due course.

The action of a flywheel is referable to gravity, according to the formula

$$\frac{m \times (v)^2}{2g, \text{ or } 64\cdot4} = \text{work in foot pounds stored in the rim,}$$

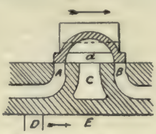
where m = weight of rim in lb., v = velocity of rim in feet per second. The weight of the arms is not calculated. The diameter of a flywheel is, therefore, of little importance—some engines have small, others large ones; the mass and velocity are the points of importance. The velocity of the rim calculated may vary within from one-fiftieth to one-eightieth of the mean velocity without affecting steady running. A flywheel much too light or too heavy is an evil. The function of the wheel is to prevent acceleration by absorbing excess of pressure; and to prevent retardation, by giving out of its stored energy when the pressure is insufficient.

The Valve Motion. The methods by which the admission and exhaustion of steam are controlled by the rotary motion of the crank shaft would be more astonishing were they not so familiar. It is not merely that a constant volume of steam is admitted on each stroke, as in the simpler types, but that the supply can be rendered variable within minute limits, to counteract unequal loading or rates of running of the engine. The subject of these valve gears, and the methods by which they control the valves, would fill a large volume. For the present we take a plain valve of the sliding type—the *slide valve*, actuated by a plain eccentric directly—and consider its mode of action.



6. OBLIQUITY OF CONNECTING ROD

All the steam for use in the cylinder must come through the steam chest [**5**]. There are three passages which afford communication between the steam chest and the cylinder; the *steam passages* through which live steam enters to each end, and through which also steam, having done its work, exhausts back under the valve, and out through the third or *exhaust* passage, communication with which can take place only under the arch of the D slide valve. The valve controls the opening and closing of the *ports*—which are the openings of the steam passages that abut on the steam chest.



7. VALVE WITHOUT LAP

We can study the action, in the first place, in a type of valve that is obsolete —namely, that in which no provision was made for the expansive action of steam [**7**]. In this diagram the valve, about to move in the direction of the arrow under the pull of the eccentric rod, is beginning to admit steam to the passage A behind the piston D, moving it in the direction of its arrow. The piston, in sweeping through the cylinder, drives out all the spent steam in the space E, back through the passage B, and under the arch, *a*, of the valve, whence it escapes through the exhaust passage C, either into the atmosphere or into the condenser.

Observing the fact that the outer edges of the valve when in the central position coincide exactly with the outer edges of the ports, it is not difficult to see that the initial introduction and the final exhaustion of the steam must coincide *exactly* with the terminal positions of the piston. This is obviously a bad arrangement, because live steam continues to enter the cylinder during the whole of the piston stroke, and the exhaust steam does not escape readily at the beginning, and therefore offers resistance (back pressure) to the approaching piston. To obviate these evils is the object of lap, and lead.

Lap. The term *lap* signifies a supplementary extension of the valve, by which its edges extend or lap over the openings of both the ports to a definite amount, which is measured when the valve is in *middle travel*. It represents an amount by which the steam passage can be closed *before* the piston arrives at the end of its travel, so permitting the steam behind the piston to work expansively beyond the point at which it is cut off. Suppose the valve has a lap of $\frac{1}{2}$ in. and that such an addition will cut off the steam at half-stroke, then, during the second half of the stroke, no more steam being admitted, the volume closed within the cylinder will work by its elastic force only, or expansively.

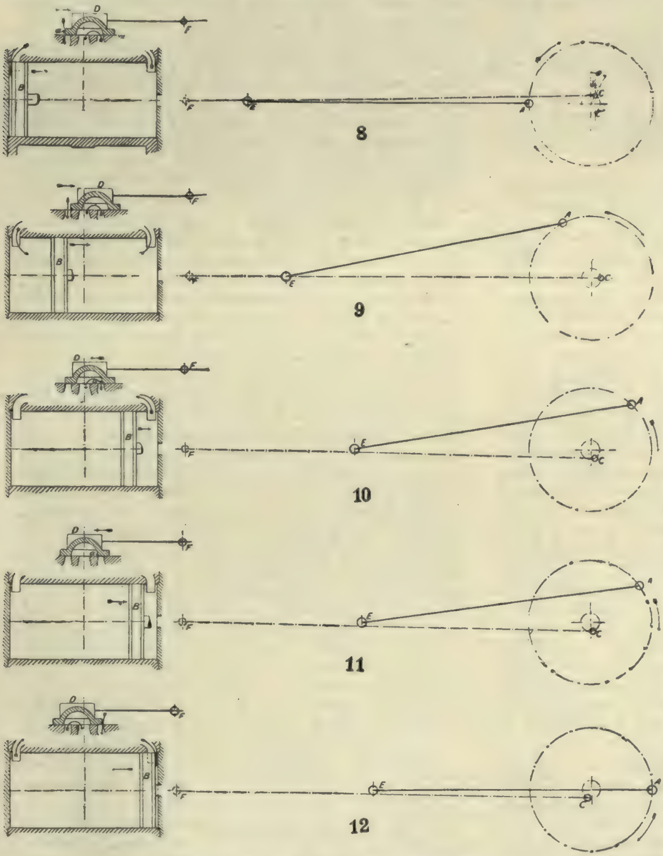
Now, it is clear that the addition of $\frac{1}{2}$ in. of lap to the normal valve requires that the eccentric, instead of having its eccentricity at right angles with the crank, shall have its eccentricity $\frac{1}{2}$ in. in advance (linear advance) of the crank, or it would not open the valve [**8**, *b*]. Such an arrangement is termed *fixed expansion*, when the amount of advance cannot be altered. But most engines now have *variable expansion*, effected either at the eccentric itself or

by link motions, of which there are several types, which include provision for reversing the direction of motion of the engine.

Lead. Returning to **7**, we observe that the steam must enter with difficulty at the beginning of the opening of the valve, and if fittings were loose it might hardly get in at all. But now, if the valve be set by the eccentric so that the valve is open slightly [**8**, *a*] when the piston is at the end of its stroke, ready to return, some steam will enter. The amount of opening, *a*, left (*lead*) is not much, usually from $\frac{1}{32}$ in. to $\frac{1}{16}$ in., but it is sufficient. The linear advance of the eccentric then has to equal the amount of lap plus the lead. The method of setting this out is shown on the diagram [**8**], to which further reference will be made.

Nor is this the only advantage of lead, but the small volume of steam thus admitted (*pre-admission*) acts as an elastic buffer or cushion (*cushioning*), to bring the piston quietly to rest before it starts on its return stroke. Lead is also given to exhaust, to facilitate the escape of the spent steam, and so lessen the loss of power due to the imprisonment of an excessive amount of steam on the exhausting side of the piston (*back pressure*).

Back Pressure. The reciprocating parts which acquire momentum in their movements are the piston and its rod, the crosshead, and the connecting rod. In modern engines these travel at speeds of from 300 to 600 ft. per minute, with corresponding momentum. As they are pushed with a power of, say, from 50 to 150 lb. on each square inch of the piston area, the same back pressure is required to bring them to rest before reversal; hence the value of a cushion of steam. But for this cushion the joints of the crank pin, the crosshead, the piston and its rod, and the bearings of the crank shaft would be much more severely shocked than they are. This is a very important practical point in the working of engines. The back pressure becomes an evil only when it offers excessive resistance to the proper movement of the piston. Back pressure may also be considered to afford some compensation for the large clearance space of the steam passage. As it is exhausting steam that is compressed, if the compression continues up to boiler pressure the passage will be filled with steam of equal pressure with that about to enter. Then, too, the opening to lead may be very small, or from $\frac{1}{32}$ in. to $\frac{1}{16}$ in.



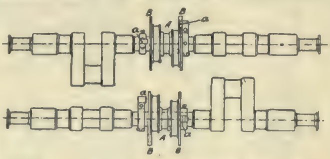
DIAGRAMS OF VALVE MOVEMENTS

Wire Drawing. This term signifies reduction of steam pressure as it enters the cylinder. This may be due either to reduction of pressure at the throttle valve, or the regulating valve in the steam supply pipe, termed *throttling*, or by having the steam passages in the cylinder too small. In either case wire drawing is an evil, and it can readily be detected by an indicator diagram. One great advantage of the use of automatic expansion gear is that the steam supply to the cylinder is controlled exactly by the cut-off of the valve or valves, at varying points in the piston stroke, without wire drawing or reduction of pressure.

Operation of a Simple Valve. The diagrams **8** to **12** illustrate the successive stages of the slide valve with lap and lead through a complete cycle. In these diagrams the full lines AE represent the connecting rod, and the broken lines CF the eccentric rod. The valve rod extends from F to the valve D. The length of the piston rod is not shown—it is, of course, a matter of no moment—neither is that of the valve rod, each being always in one plane. Only the rods which have obliquity control the essential relations. The valves in each diagram are shown for convenience as removed from the back or side of the cyinder to a location above.

In **8** the *crank pin*, A, is on dead centres nearest to the engine, and the piston, B, is momentarily at rest, compression having taken place by the admission of steam through the port opening to lead at *a*.

The eccentric sheave has its greatest eccentricity at C. The distance *b* is the *linear advance* of the sheave = lap + lead, and θ is its *angular advance*. The advance is reckoned from a line at right angles with the line that connects the crank pin and crank shaft. In whatever direction the eccentric is set, it *leads the engine* by opening the suitable port. Thus, in **8** the eccentric, C, has drawn over the valve, D, to open the port to lead, *a*, so admitting steam behind the piston, B, and the piston must therefore move in the direction of the arrow, and the crank rotate in the direction of its arrow. Clearly, movement could not take place in the other direction. But if, the crank pin remaining at A, the eccentric were located at C^1, it would lead the crank pin in the direction of the dotted arrow, and the engine would be *reversed*.



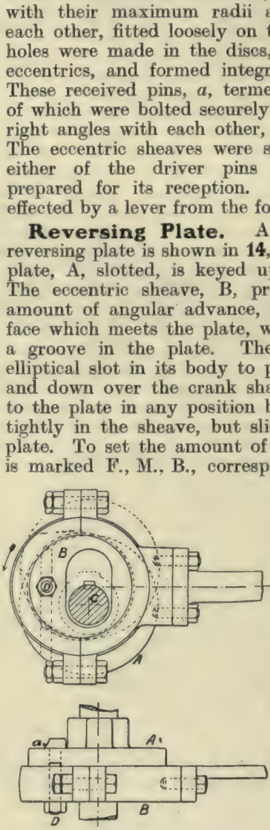
13. REVERSING ECCENTRICS IN PRE-LINK MOTION PERIOD

In the next [**9**] the eccentric, C, has moved sufficiently to open the induction port fully, and the full boiler pressure is being exerted behind the piston. The steam from the previous stroke occupying the area in front is exhausting freely. The eccentric being now on its *dead centres*, its backward movement begins, and the next [**10**] shows that the valve has returned and closed the admission port. From that moment the steam at boiler pressure in the area behind operates against the piston by virtue of its own elastic force or expansion, and gradually the eduction port is being closed by the inside, *a*, of the valve, and a certain amount of back pressure is beginning to take place. In the next [**11**] the valve is nearly in middle travel, lapping over both ports, no steam entering and none exhausting, for the edge, *a*, has covered the exhaust port; hence there is expansion going on on the left-hand side of the piston, B, and cushioning on the other. The fact is now apparent how inside or exhaust lap, or lead, at *a* can be made to control the amount of cushioning. If there is inside lap the escape of the steam is delayed; if inside lead, it is accelerated. Finally, in **12** the stroke is completed, and the valve has opened the other port to lead for steam admission, the crank pin is on dead centres 180° from its first position, and the cycle begun in **8** is beginning for the return stroke.

Types of Eccentrics. Eccentrics are of two kinds—fixed and movable. The latter are either reversing simply, or of both reversing and expansion types. With the fixed eccentrics, reversing and expansion can be effected only through the medium of a link motion. This is fitted to practically all large stationary engines and locomotives, but very many small engines are without it, as it is unnecessary for the class of work which they have to perform. It is not required when an engine always has to run in one direction, when steam is worked expansively by a fixed amount of lap on a common slide valve, and of angular advance embodied in the fixed eccentric, and when a moderate variation from normal speed is not objectionable, such as could be secured by a governor action on the throttle valve. All smaller commercial engines are included in this class.

There are, however, a fairly large number of engines in which it is desirable to make a less expensive provision for occasional reversing and expansion than that which is afforded by link motions and by a governor actuating the cut-off of the slide valve. The *expansion eccentrics* here fill a useful place. Substantially, they comprise a circular plate permanently fixed to the eccentric shaft, and an eccentric sheave free to move round an arc of the shaft, with provision for bolting it to when set at certain angles to the fixed plate. Perhaps everyone does not know that the early locomotives were fitted with loose eccentrics to effect reversal of the engines before the link motion was invented. Figure **13** illustrates one of these from De Pambour's treatise on locomotive engines, showing them as made in 1840—the loose eccentric sheaves, A, cast in one piece, with their maximum radii at right angles with each other, fitted loosely on the crank axle. Two holes were made in the discs, B, that flanked the eccentrics, and formed integral portions of them. These received pins, *a*, termed *drivers*, the bodies of which were bolted securely to the crank axle at right angles with each other, and with the cranks. The eccentric sheaves were slid endwise to cause either of the driver pins to enter the hole prepared for its reception. The movement was effected by a lever from the footplate.

Reversing Plate. A good example of a reversing plate is shown in **14**, complete. The main plate, A, slotted, is keyed upon the crank shaft. The eccentric sheave, B, provided with a fixed amount of angular advance, has a tongue on the face which meets the plate, which tongue slides in a groove in the plate. The sheave also has an elliptical slot in its body to permit it to move up and down over the crank shaft C. It is clamped to the plate in any position by the bolt D, fitting tightly in the sheave, but sliding in a slot in the plate. To set the amount of expansion, the plate is marked F., M., B., corresponding with forward, middle, and backward travel. The head of the bolt D is prolonged into a pointer, *a*, which is set to either division required and there clamped. Divisions may also be inserted for different grades of expansion.



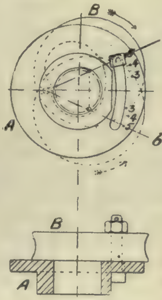
14. REVERSING ECCENTRIC PLATE

Expansion Eccentrics. Figure **15** illustrates the expansion eccentric by Ruston, Proctor & Co., Ltd., as made for many of their portable and fixed steam engines. A is the circular plate keyed on the crank shaft. The sheave, B, is secured to this by a bolt, C, which passes through a curved slot in the plate A. The total range for reversing and expansion is indicated by the diverging dotted lines *a*, *b*, at which positions steam is cut off at one-half the stroke, the engine running in the direction of the arrow when the bolt C is tightened at one end or the other of the slot. If in the position ·4 and ·3 respectively, the steam is cut off at four-tenths and three-tenths respectively of the stroke.

The Limitations of the Slide Valve. High rates of expansion cannot be obtained with the common slide valve, because the expansion is governed by lap, and increase in lap requires

increase in the angular advance of the eccentric, and such increase causes early closing of the exhaust, as well as early cut off, and this produces too much back pressure. To a considerable extent the question of back pressure is determined by the class of engine. In slowly-running engines a large back pressure is objectionable. In fast-running engines it is advantageous. In locomotives, for example, the common valve is used, and a large amount of cushioning is desirable on account of the very high momentum of the piston.

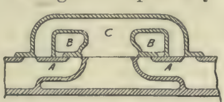
Another objection to the slide valve covering the three ports at or near the middle of the length of the cylinder is the loss occasioned by the *clearance spaces* occupied by the passages. The entire length of a steam passage is about half as long as the cylinder, and the volume of steam contained in a passage may be equal to about one-thirtieth of the volume of the cylinder. The greater portion of this steam is wasted at each stroke, going out with the exhaust steam on the return of the piston.



15. EXPANSION ECCENTRIC

When high economies and high rates of expansion are required, and slide valves are still retained, then two valves are used, the *main valve* moving over the ports, and an *expansion*, or *cut-off valve*, on the back of the main valve. The opening and closing of the exhaust port are then controlled by the main valve and the steam lap, and cut-off by the expansion valve. Though these arrangements do not avoid the evil of long passages with clearance losses, they lessen the excessive back pressures. If long passages are to be avoided, separate valves and passages must be used at each end of the cylinder, or the Corliss, or Drop valves must be adopted.

Automatic Expansion Gear. This gear is that which is effected by the governor acting on the slide, or steam supply valves to the cylinder. It effects *variable* expansion, meaning by that, degrees of expansion which vary from moment to moment with every variation of load on the engine It differs, therefore, from *hand expansion* gear, effected by the adjustment of back cut-off valves, and of the expansion eccentric adjusted on the face of a fixed plate. It is also distinguished from expansion effected by link motions, which, though capable of producing immediate variations in degrees of expansion, are nevertheless not usually automatic in action, but are put into operation by the hand of the engineman. In some cases, however, the governor is made to operate on the link motions, and so control them in an automatic manner.



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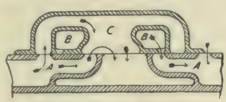

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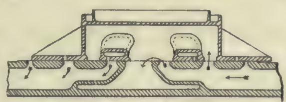


18

DOUBLE AND TREBLE PORTED VALVES

The value of automatic expansion gear lies in this. When the load on an engine varies, or is liable to vary constantly, and yet a steady, uniform rate of driving is desirable or essential, then the automatic gear is instantly responsive to changes in speed, and corrects those changes in their incipient stages. The governing differs from that of ordinary governors, which act on the steam supply valve—the *throttle valve*—in acting instead on the *slide valve*. The difference is an important one, although, on first thoughts, it might seem a matter of indifference whether the steam supply is regulated in the supply pipe, or *after* it gets into the steam chest. But actually minute adjustment is not practicable in the first, while it is in the second. The steam space intervening between the throttle valve and the steam chest is too large to admit of instant results following, and if the steam supply is largely reduced, wire drawing takes place in the passages. But if cut-off is effected by the slide valve the effect is instantaneous on the speed of the engine.

Relations of Passages and Ports. In the type of valve we are considering [5] the same passages and port openings are used alternately for both supply and exhaust. This is not an ideal arrangement, and is one of the reasons for the preference often given either to Corliss valves, or to Drop valves, in which the functions of the passages are separated. It is essential to the free working of an engine that there should be no impediment to freedom of exhaust, for if there is, a corresponding amount of back pressure is set up. This has to be overcome by the pressure of the incoming steam on the opposite side of the piston, so throwing unnecessary work upon it. This back pressure is an evil, and as such must be distinguished from the slight amount of cushioning produced by the small amount of lead given after the steam has exhausted, and at the instant that the piston comes to rest.

In the common valve, when the valve is at full stroke, and the steam supply port full open, the exhaust side of the valve has travelled beyond the edge of the port from which exhaustion is taking place. The amount of overlap equals the outside lap minus any inside lap allowed. Consequently, when the supply port is closed, the exhaust port is open only by an amount equal to the outside lap minus inside lap. If the width of the ports is made to correspond with this exactly, the same area will be opened to exhaust as to steam, whereas the former ought to be in excess of the latter. This is often accomplished by making the ports of greater width, and causing the valve to open the port to steam only partially, and to open that to exhaust fully. This design is termed the *exhaust relief* valve.

The same principle is carried a stage farther in the double and treble ported slide valves.

Double and Treble Ported Valves. In the double ported valves [16] the steam passages, A, open out into two ports instead of one. Compare with **5**. The steam enters both outside and through the body of the valve, BB, at once, and exhausts also into the arch, C, through two ports, which are fully open when the valve is at full stroke. Hence, also, the travel of this type of valve is only equal to one-half that of a single ported valve having an equivalent port opening. Figure **17** shows the valve as it appears when fully open to steam and fully exhausting. Treble ported valves [**18**] are an extension of this design, three ports opening into each steam and exhaust passage. Beyond this the designs of this type of valve do not go; if less movement is required, and sharper action, the Corliss, and Drop valves are used.

Continued

Group 20
LEATHER
20
Continued from page 5482

RECIPES FOR LEATHER-WORKERS

Some Proved Recipes for Bleaching, Dressing, Finishing, and Preserving Various Leathers. Dictionary of Leather Terms

A FITTING conclusion to the course on the leather industries will consist of some practical recipes for the use of leather-workers. The recipes which follow on this page have been compiled by one of the first leather experts in the country, and have been proved and found excellent for their specific purposes.

CURRIERS' SIZE. Boil ¾ gal. of glue size and add ¾ pt. soft soap, ¾ pt. curriers' grease, and 1½ pt. of milk. Strain ready for use.

KID SIZE. Take cuttings of calf kid that have been tawed, and cover them with water and simmer them for a few hours. Apply with a sponge. If required black, add a sufficiency of bone-black.

PASTE FOR FILLING SPLITS AND KIPS. Mix 1 lb. of rye or household flour with 1 oz. of resin, 1 oz. of white curd soap with 4½ oz. of clear glue, and 14 oz. of best tallow. Add a few drops of ammonia. Another recipe is 1 qt. of flour, 2 oz. of tallow, 1 oz. of resin, 1¼ oz. of beeswax, 3 oz. of soap.

COLOURING FOR WAXED BUTTS. Mix together cod oil and vegetable black, and apply to leather previously slicked, cleansed, and sized, with a brush; or a sizing of gelatine may be given first, the leather glassed, then apply the above.

LEATHER FINISHING SIZE. 4 oz. of gelatine is placed in 5 gal. of soft water until swollen and softened. When this has taken place, it should be subjected to heat in a water bath, stirring the while. To this is added the following: 6 oz. of linseed oil, 2 lb. of carnauba wax, 1½ lb. of white curd soap, and the mixture is heated until thoroughly dissolved. A little dye used to stain the skins is sometimes added. One or two coats may be given. When dry, polish with woollen cloth.

TO IMPART A DULL LUSTRE TO LEATHER. Dissolve curd soap in lukewarm water until a syrupy solution is formed. Sponge this evenly over the leather, and when dry polish by rubbing with a woollen rag.

BLEACHING LEATHER. Carefully go over the leather to be bleached with a moist sponge, so that the whole of it is evenly moistened. This application is improved if sal ammoniac is added to the water. By applying peroxide of hydrogen with a cloth or clothes brush, the leather will be bleached. Repeat the operation until bleached sufficiently.

Dissolve borax in water, about 1 lb. to each 3 gal., and soak the leather. Dip the leather in sulphuric acid and immediately wash in soft water. Put the leather in a drum with hot sumach solution, adding a $\frac{1}{36}$th part of muriate of tin.

TOPSIZE, OR FINISH FOR BLACK LEATHERS. Dissolve white shellac in water and borax, with the aid of heat. Add nigrosin for colouring matter, and allow to cool. Put on with a sponge or China moss dissolved in water and boiled for a couple of hours.

SHOEMAKERS' WAX. Take equal quantities of pitch and resin, and add, according to the state of the weather, tallow. Pour the mixture, after heating, into cold water, and pull it until it is able to float on the water, taking care to keep the hands well wetted, to prevent it adhering to the fingers.

SADDLERS' WAX (BLACK). Take 1 lb. pitch and 1¼ lb. resin, and mix with a sufficiency of seal oil. In cold weather, add ¼ lb. less resin. Bone-black can be added to make it very black. After the pitch and resin has been melted, add the oil, the amount varying with the time of year—winter or summer. Pour the mixture into cold water, and knead and pull it until it floats.

SADDLERS' WAX (BROWN). Take of light-coloured resin 1½ oz., of white lead 1½ oz., and of beeswax ½ lb. Prepare as for black wax.

HARNESS BLACK DYE. Take 20 parts water, 4 parts logwood chips, 1 part nutgalls (powdered), and 2 parts copperas, with a little gum arabic, to add a consistency to the mixture. A drop or two of ammonia adds to its striking power.

PERMANENT BLACK INK. Take 1 lb. logwood chips and 1 gal. water, and boil for half an hour. Then add ⅛ oz. of bichromate of potash. When cold, add the solution made by dissolving glue in water.

PASTE FOR POLISHING BROWN LEATHER. Melt together 1¼ lb. of beeswax and ¼ lb. lard, adding, when mixed, ⅛ lb. of oil (neatsfoot). When it has half cooled, add ¼ lb. of turpentine, with dragon's blood or similar colouring agent. Rub the mixture when cool on the leather, brush it well, and afterwards finish the polish with a rag.

TO KEEP PATENT LEATHER SOFT AND LUSTROUS. Melt white wax over a water bath, adding a little pure olive oil and rectified lard, and mix by stirring and adding oil of turpentine. Allow to cool, and when wanted, rub a little on the patent with a rag, and polish.

SHOE DRESSING. Take 1 lb, of gum tragacanth and ½ pt. of cod oil, and put them to dissolve overnight. Next day pour on ¾ gal. of boiling water and allow to stand for 5 or 6 hours. Stir well and add more water gradually, day by day. This dressing gives a moist, soft feel to the leather.

A SHORT DICTIONARY OF LEATHER TRADE TERMS

ADHESIVES—Pastes, starch, glues, soaps, dextrins and rubber solution used for sticking leathers.

BACK-STRAP—A thin strip of leather placed inside a seam to protect it.

Bagging — The process of closing which consists of seaming two pieces together, and then turning it out and closing a second row.

Balance-wheel—The name given to the wheel at the side of the sewing-machine. Used when making half-turns in raising or lowering the needle.

Bar Shoes—Shoes designed with straps or bars across the front and forming an open-worked design.

Bark-bottomed lasts—Lasts cut with the bottom facing the bark. Such lasts shrink most in width.

Bark-sided lasts—A last cut from the wood in such a manner that the sides of the last run parallel to the bark. Lasts cut this way shrink most in height.

Bating—The soaking of skins in bran and animal excrement to soften them and remove the lime.

Bazils—The skins of sheep; skins that are tanned for shoe-linings.

Beading—The insertion of a thin double strip between two other pieces of leather so as to show the folded edge of the thin piece.

Belly—The portion of a hide or skin that covers a similar portion of the animal from which it is taken. It is very flexible and loose.

Bespoke—Shoes made to the individual order of a customer. Shoes to measure.

Bevel—The skive or slant of a piece of leather. Varied according to the thicknesses of the leathers lapped.

Bevel-toe—The toe of a last which bevels or slants considerably.

Block - fitting — The method of fitting uppers on the block, which is shaped like a last.

Blocking—The process of welting leather and pulling to a given shape.

Boots—Shoes that are cut to cover over the ankle-bones.

Bottom-width—This term is applied to the widest part of the last in the fore part. They vary 1-12th inch for each size.

Box - calf — Calfskins dressed by chroming, with a rubbed-up marking on the grain side.

Braced—The sewing of the upper to the inner sole by an over-and-over seam. Resorted to when nails are undesirable.

Buffed—Scraped with a steel scraper until smooth.

Button-fly — The portion with the buttonholes cut in on a button boot.

Butts—The section of the hide that adjoins the lower end of the backbone. Considered the best portion of the hide.

CALF - KID — A dull-faced, soft supple leather, tanned by alum, etc. Is easily softened by soaking.

Calf-patent—Calf skins stretched, and enamelled on the flesh side with an elastic varnish.

Cement—A term used to describe the solution made by dissolving virgin rubber in naphtha. Used in shoe-work for export trade to prevent germination.

Ch ome-calf—The skins of calves dressed by the mineral chrome process. Distinguished by the green appearance in cut section.

Clicker—A person who cuts up upper leather.

Closer—The person who fits together and stitches the uppers of shoes.

Closing—The art of putting together and stitching the various parts of shoe uppers.

Comb—The ridge on the top of the instep of a last which extends backwards to the heel portion.

Comb-lasts—Lasts made all in one piece without the usual sectional piece are termed "comb" lasts. They are usually smaller than required, to allow of a piece of leather being inserted.

Corium—The true skin. The portion which forms the pelt and is used to make leather.

Counter—The stiffener used at the back of a boot or shoe, and composed of various materials, such as leather, cardboard, pulp, and canvas.

Currying—The infusing of leathers with greases and waxes.

DEAD-WAISTS—The waists of lasts that are flat.

Depilation—Removing the hair from the skin previous to tanning.

Derbies—The shape of boot with an outside quarter cut to a point which is placed over the vamp. It is the shape largely used for shooting-boots.

Dextrin—Otherwise called British gum. Used for sticking together greasy leathers. Not much used for lighter varieties owing to its stiffening properties.

Draft—Is a property imparted in footgear, the result of pulling the upper in given directions. It tends to counteract the spreading of shoes caused by the intermittent pressure transmitted during usage.

Drafting—The alteration of the curve of a portion of a boot with the object of ensuring a tension at that part to oppose any strain put upon it during wear.

Draft-plan—The outline of the foot that is made by pencilling round it with an upright pencil.

Drop-feed—The feed of a sewing-machine which, after it has moved forward the requisite amount, lowers itself on its return.

Drop-waists—The waist of lasts that are arched are termed "drop-waists."

FACINGS—The inside strip of leather placed under or over the edge of the boot where the eyelets are placed. It is used to give support to the strain caused in lacing.

Feather—The reduction of the edge of an insole to prevent it curling or hurting the wearer's foot.

Finishing—The process of knifing, rasping, sand-papering, inking, ironing, and burnishing the edges and bottoms of boots.

Fittings—The inside portions of the boot, such as top-bands, facings, straps, and linings are termed "fittings." The word is also used to express the different widths of a given size.

Flesh—The under portion of leather—that which comes near the "flesh" of the animal. Is distinguished by its rough appearance.

Fleshing—The process of removing the bits of flesh from the back of the skin before tanning.

Forme—This term is applied to a shape which is sufficient to cover one side of the upper portion of a last. It is in shape like a last, and is from the French *forme*—a last.

GARIBALDI—The shape of the front portion of a boot that consists of a fancy strap made continuous with the vamp. Largely in vogue in elastic-sided boots.

Glove-kid — Skins usually from the kid, but sometimes from the lamb, dressed by the tawing process. They are soft and supple, but easily wetted.

Golosh—The name of the whole-cut vamp. An over-shoe.

Grain—The name given to the top portion of the leather, that which comes nearest to the epidermis of the real skin. Also used to signify a smooth leather well stuffed with grease.

Growth-marks—The technical name given to the shiny lines found on the shoulder portions of many skins.

HAND-SEWN—The method of bottoming that consists of a welt sewn in with the upper to the insole. Afterwards the sole is stitched to the welt.

Heel-measure—The distance round the foot at the sharp bend in the front round the heel portion.

Heel-plate — The name given to the metal plate found on the seat of some lasts. It enables the heels to be nailed on, the metal plate clinching the nails.

Hides—Skins taken from the backs of the larger animals, such as oxen or buffalo.

Hinged Lasts—When the last is sawn in two to make it easy of withdrawal and insertion in a boot, and the parts are hinged together, they are known as hinged lasts.

Horsing—The raising or lowering of the upper at the seat when pulling it over the toe of the last for lasting It increases the tension from seat to toe.

INSOLE-SHAPE—The design cut to fit the bottom shape of the last.

JOCKEYS—A long boot cut with a tongue and seamed back. Has a coloured top leather.

Joint-line—The position in a pattern where the joint measure is taken.

KANGAROO—The skin makes a very fine, light, and tough leather. It is dressed in various ways, such as tanned with gambier, tanned with alum, into dull leather and glazed like glaces. It is also enamelled.

Kips—The skins of small animals not fully developed are termed kips. There is much speculation as to its exact meaning in this direction. It is also used to signify skins of chamois.

Knifing—Shaping the edges of boots to prepare them for the burnishing process.

LANGTRIES—A design of shoe with a rounded latchet front.

Laster—The workman who pulls the upper to the last, and thus imparts the requisite shape.

Last-fitter—The man who takes a stock-shaped last and leathers it up to suit individual requirements.

Lasts—These are models designed to represent the mean action of the foot's motion for a particular purpose, over which the shoe is made. Sometimes said to be models of the human feet.

Last-spring—If the toe of the last rises or curves upward from the table, this elevation is termed "spring." It varies with the stoutness or lightness of the boot as well as the gait of the person for whom the last is intended.

Latchet—The tab of the front portion of the quarter of a Derby or tie-shoe.

Leg position—The relation of the leg portion of the boot to that part which clothes the foot proper. May be either forward or backward leg position.

Levants—Is a term used to classify leather with a pebbly grain, originally from the Levant. Often used to denote an artificial printed leather.

Lift—see *lifting*.

Lifting—The pieces of leather used to build up a heel are termed *lifting*. The bottom lift near the ground is called a top piece.

Ligaments—Bands of fibres that knit together various portions of the foot.

Line of contact—The place on the bottom of the last which touches the ground when the last is placed in its right position for the kind of heel required. It is important in determining the shape and proportion of a last.

Lines of tightness—The directions in which the skin pulls tight when subjected to a pulling strain. The observance of them in cutting and making footwear is important.

Liming—The process of steeping skins in lime-water to loosen the hair and outside skin.

Long-heel—The measurement of the foot from top of instep to the heel portion.

Long-work—Is a term given to boots that are cut higher than short boots, and reach to the calf or higher.

MACHINE - SEWN—This is also known as Blake or McKay sewn. It is a chain-stitch that goes right through the sole, middle sole, upper and insole in a vertical manner. The majority of factory boots are made on this principle.

Machine-welted—A boot made on the same principle as hand-sewn, but the welt and sole are machine-sewn and stitched respectively. Known also as Goodyear welted.

Memel calf—A skin dressed on the grain side and boarded to give a very fine, pleasing grain. Much used in Scotland.

Mineral tanned—Tanning performed by chemicals in contrast to vegetable tanning. Chrome leather is a sample

OFFAL—The portion of the hide that is inferior in quality, as the bellies, cheeks, and faces.

Ooze-calf—A soft chromed leather with a pebbly grain and fine, velvety back.

Orthopædic—A term applied to footwear for shoes fitted and suitable for cripples.

Oscillating shuttle—A shuttle which travels to and fro in a restricted arc of the circle.

PASTE-FITTING—The process in fitting together the various parts of an upper by paste prior to its machine-stitching. It comprises skiving, turning in, and other similar processes.

Patent—A leather which has an enamelled face of shiny varnish is termed *patent*. It is so called owing to the process of preparing originally being a patent.

Pattern-making—The art of designing and cutting patterns to lasts for boots and shoes. They are made in paper, cardboard, metal, and card with metal-bound edges.

Pawl—A bent sector piece of metal which engages with the ratchet in a sewing-machine.

Pedistat—An instrument for measuring exactly the human foot.

Pegged—The method of bottoming which uses pegs of wood to fasten the sole to the upper and insole.

Pelt—The skin after the epidermis, hair, and flesh have been removed. The true skin. That portion which the tanner converts into leather.

Pitch—The provision in a last to accommodate the height of heel.

Porpoise—The leather from the porpoise. Is a very durable and tough leather. Used for shooting-boots and laces.

Puff—The thin piece of skived leather placed under the toe of the upper to keep the toes from injury.

Puff-toe—A toe of last that is high and round.

QUARTERS—The back region of a boot or shoe.

RAW EDGE—When a piece of leather is laid over another without turning in it is said to be *raw edge*.

Reciprocating shuttle—A form of shuttle—usually boat-shaped—which travels to and fro in the shuttle-race.

Riveting — A process of fastening the soles to the inner soles by means of brass rivets. Often used in cheap repairing.

Roans — Sheepskins with a grained face, used for linings.

Rotary shuttle—A shuttle which rotates completely round in a circle. The highest form of high-speed mechanism.

Roundings—The name given to the poorer parts of leather, thrown out when cutting up skins. The edges or skirting of skins.

Russet-calf—The calfskin in the crust before it has been curried or blackened.

Russia—The name of a brown birch or larch dressed calf. Distinguished by its odour, due to birch oil.

SANDALS—A low form of shoe which leaves the foot fairly free.

Satin-calf—Sometimes also known as *flat-calf*. A calfskin dressed in the grain, but finely buffed to a smooth face.

Satin-hide—The split hide of the buffalo. The grain is buffed or scraped, and thus produces a very fine face—hence the name.

Scale—A range of sizes and fittings suitable for lasts.

Scouring—The process of removing the dirt and smoothing the skins preparatory to leather finishing.

Seat — The portion of the boot immediately over the heel. In hand-sewn work the seats are either pegged or sewn.

Second-lasted—After a turn-shoe is sewn it is turned and then placed again on the last. This is termed *second-lasting*, as it imparts the shape of the last to the upper.

Sectional Lasts — Lasts made in several pieces to facilitate the withdrawal from the boot after it is made are termed *sectional* or *easy exit* lasts. Several forms are covered by patents.

Sew-rounds—The process of making shoes inside out. The inseam is placed all round the sole and upper. See also *turn-shoe*.

Shanks—The portions of leather that cover the hind-legs of the animal from which the skin is taken. Also the waist or narrowest part of the sole of the boot.

Shoes—Shoes that are cut below the ankle-bones.

Shoulder—That portion taken from the shoulder of a skin. Is usually fine and tough.

Shover—A leather fitting made to go down the front of the last to increase its measurement.

Side- lace—A boot to lace at the side instead of in front. A very comfortable form of boot.

Side-spring—A boot cut with elastic gussets at each side.

Size-stick—An instrument used for measuring lengths of feet and lasts. One size equals one-third of an inch.

Skins—The names of hides taken from the backs of the smaller animals.

Skived—The bevelling or reducing of the edges of leather to allow one portion to lap over another.

Slabs—Under-splits of leathers cut into two or more sections.

Slack-thread—The thread paid out through the eye of a machine needle to allow the shuttle to pass through.

Slipper-lasts—Slipper-lasts are shaped more like the foot in a position of rest, and are used to make low-heeled shoes—such as slippers.

Sole-shapes—This is the term given for the shape used to make the bottom portion of the last. It corresponds to the insole shape.

Sole-area—That portion of the foot which, if coloured with a dye, would make an impression on paper.

Specials—A term used to designate bespoke or custom work

Split—The name given to the flesh portion of a split hide. If waxed, known as *waxed* splits.

Shoemaker's Paste—Made from flour —usually rye—fermented to produce smoothness. Glue is often added to give body. An excellent paste for sticking.

Standard — The first pattern cut for uppers. It is usually size 4 for ladies, and size 8 for men. Other sizes are made from the standards.

Stiffener—see *counter*.

Straights—The form of last which determines boots with both sides alike. A symmetrical last.

Stretch—When a piece of leather is subjected to pulling and it gives—this giving is termed *stretch*. Stretch varies in different portions of the skin, and is influenced by tanning.

Stuffing—The art of forcing fats and waxes into leather during currying, either by hand or drum.

TANNIN—The astringent property found in most vegetable products, chiefly extracted from barks and seed-pods.

Tawing—The process of preserving skins by treating them with alum and salt. The skins so produced are soft and stretchy.

Tension—The strains set up in leather during lasting. The pull put on a thread in a sewing-machine.

Tongue—The strip—single or double—of leather found under the eyelets in a lace boot.

Top-bands—The pieces of leather found inside the top edge of boots.

Trimmers—A short blade inserted vertically close to the needle which trims the material at the same time as it is closed.

Turning-in—The edge of leather folded under so as to show a smooth, rounded edge.

Turn-shoe—A shoe that is made inside out with an insole, and afterwards turned. The most flexible form of making shoes.

UNDERLAYS—The portion of leather that goes under the lap of a seam.

Uppers—Also called "tops." The portion of the boot that covers the upper surface of the foot.

VAMP—The front portion of the shoe.

WAX-CALF—The skin of the calf tanned, curried and blackened on the flesh side.

Wellingtons—A long boot with side-seams from top to bottom.

Welted—The process of bottoming shoes, using a welt as an intermediary for attaching the sole.

Wheel-feed—The feed of a sewing-machine formed by a serrated periphery of a wheel.

White whale—A leather often sold as, but inferior to, porpoise.

Wing—The portion of the vamp or front of the boot which runs into the waist or shank. Also applied to a form of toecap that has long sides.

LEATHER *concluded ; followed by* WOOD-WORKING

Continued from page 5520

ITALIAN

Continued from page 5370

By Francesco de Feo

CONJUNCTIONS

CONJUNCTIONS are used to indicate a relation between two propositions, as: *Mio fratello scrive che sarà a Londra fra qualche giorno*, My brother writes that he will be in London in a few days; *Pietro e Carlo lèggono* (*Pietro legge, e Carlo legge*), Peter and Charles are reading.

Conjunctions are invariable, and are either *simple* or *compound*.

(*a*) Simple conjunctions are:

e (before a vowel, also *ed*), and
nè (*nèh*), nor
o (before a vowel, also *od*), or
che (*keh*), that
ma (*mah*), but
anzi (*àhn-dzee*), on the contrary
se (*seh*), if, whether
dunque (*doòn-koo-eh*), then, so, therefore

(*b*) Compound conjunctions are:

oppure (*oppoò-reh*), *ossia* (*osseè-ah*), *ovvero* (*ovvèhro*) } or
eppure (*ehppoò-reh*), and yet
ebbene (*ehbbèh-neh*), well
sebbene (*seh-bbèh-neh*), although
perchè, why, because
dacchè, since
poichè, as
purchè, provided that
per quanto, however
di maniera che, so that
affinchè, in order that
etc., etc.

As to their meaning, conjunctions are divided into *co-ordinative* and *subordinative*.

The co-ordinative may be divided into:

1. Copulative: *e*, and; *anche*, also, too; *ancòra*, yet, still; *nemmeno, neppure*, not even, etc.
2. Disjunctive: *o, ovvero, oppure, ossia*, or; *o piuttosto*, or rather; etc.
3. Adversative: *ma*, but; *tuttavia*, however; *pure*, yet; *anzi*, on the contrary; *d'altra parte*, on the other hand, etc.
4. Declarative: *che*, that; *cioè*, that is; *vale a dire, è quanto dire*, that is to say, etc.
5. Consecutive: *dunque*, so; *perciò, quindi*, therefore; *per conseguenza*, consequently, etc.

The subordinative conjunctions may be divided into:

1. Relative: *che*, that; *come*, as, etc.
2. Temporal: *dopochè*, after; *dacchè*, since, etc.
3. Causal: *perchè*, because; *poichè, giacchè*, since.
4. Concessive: *benchè, quantunque, sebbene*, though, although; *per quanto*, however, etc.
5. Conditional: *se*, if, whether; *qualora*, if ever; *purchè*, provided that; *supposto che*, supposing that, etc.
6. Consecutive: *di modo che*, so that; *tanto che*, so much so, that, etc.
7. Final: *affinchè, acciocchè*, in order that, etc.

Exercise LII.

1. Mio fratello e mia sorella sono arrivati oggi da Parigi. 2. Perchè non siete venuti alla stazione? 3. Perchè non abbiamo potuto trovare una carrozza. 4. Non se ne vada; aspetti che io ritorni. 5. Se mio padre me lo permettesse, verrei volentieri. 6. Il mio orològio costa il dòppio del tuo; cioè centoventi lire. 7. Ho dimenticato di prèndere il biglietto, perciò non son potuto entrare. 8. Io vi andrei, se avessi tempo e danaro. 9. Vi ho chiamato due volte, ma non mi avete risposto. 10. Egli non si è mai data la pena di restituirmi il danaro che mi deve, sebbene glielo àbbia chiesto diverse volte. 11. Gli ho mandato una lèttera raccomandata, così non potrà dire che non l'ha ricevuta. 12. Se foste arrivato prima, sarebbe stato molto mèglio.

Esercizio di Lettura—continued

Al mòversi di don Rodrigo, il nostro frate gli s'era messo davanti, ma con gran rispetto; e, alzate le mani, come per supplicare e per trattenerlo a un punto,[1] rispose ancòra: "la mi preme, è vero,[2] ma non più di lei; son due anime che, l'una e l'altra,[3] mi premon più del mio sangue. Don Rodrigo! io non posso far altro per lei, che pregàr Dio; ma lo farò ben di cuore. Non mi dica di no: non voglia tenèr nell' angòscia e nel terrore una pòvera innocente. Una parola di lei può far tutto."

"Ebbene," disse don Rodrigo, "giacchè lei crede ch' io possa far molto per questa persona, giacchè questa persona le sta tanto a cuore[4] . . ."

"Ebbene?" riprese ansiosamente il padre Cristòforo, al quale l'atto e il contegno di don Rodrigo non permettèvano d'abbandonarsi alla speranza che parèvano annunziare quelle parole.

"Ebbene, la consigli di venire a mèttersi sotto la mia protezione. Non le mancherà più nulla, e nessuno ardirà d' inquietarla, o ch' io non son cavaliere"[5]—continued.

Notes. 1. at the same time; 2. she interests me much, it is true; 3. both; 4. is so dear to you; 5. as surely as I am a gentleman.

IRREGULAR VERBS

Second Conjugation—continued

Verbs in ĕre (short)—continued

Scuotere, to shake

Past Def.—Scossi, scosse, scòssero.
Past Part.—Scosso.

Sedurre (*sedùcere*), to seduce [see *addùrre*, page 5082]

Sommergere, to sink

Past Def.—Sommersi, sommerse, sommèrsero.
Past Part.—Sommerso.

Conjugate like *sommèrgere*: *emèrgere*, to emerge

Sorgere, to rise

Past Def.—Sorsi, sorse, sòrsero.
Past Part.—Sorto.

Conjugate like *sòrgere*: *risòrgere*, to rise again: *insòrgere*, to rebel.

Spargere, to disperse
Past Def.—Sparsi, sparse, spàrsero.
Past Part.—Sparso.
Conjugate like *spàrgere : cospàrgere,* to sprinkle.

Spegnere (*spèngere*), to extinguish
Ind. Pres.—Spengo, spegni, spegne, spengiamo, spegnete, spèngono.
Past Def.—Spensi, spense, spènsero.
Past Part.—Spento.

Spingere, to push
Past Def.—Spinsi, spinse, spìnsero.
Past Part.—Spinto.
Conjugate like *spìngere : respìngere,* to push back; *sospìngere,* to press on.

Sporgere, to stand out
Past Def.—Sporsi, sporse, spòrsero.
Past Part.—Sporto.

Stringere, to tie tight
Past Def.—Strinsi, strinse, strìnsero.
Past Part.—Stretto.
Note here the expression *strìngersi la mano,* to shake hands.
Conjugate like *strìngere : ristrìngere,* to restrain; *costrìngere,* to constrain.

Struggere, to dissolve; **Struggersi,** to melt away
Past Def.—Strussi, strusse, strùssero.
Past Part.—Strutto.
Conjugate like *strùggere : distrùggere,* to destroy.

Svellere (poet. *svèrre*), to root up
Ind. Pres.—Svello (*svelgo*), *svelli, svelle, svelliamo, svellete, svèllono* and *svèlgono.*
Past Def.—Svèlsi, svellesti, svelse, etc; *svèlsero.*
Past Part.—Svèlto.

Tergere, to wipe
Past Def.—Tersi, terse, tèrsero.
Past Part.—Terso.

Tingere, to dye
Past Def.—Tinsi, tinse, tìnsero.
Past Part.—Tinto.

Togliere (*tòrre*), to take off
Ind. Pres.—Toglo, togli, toglie, togliamo, togliete, tòlgono.
Past Def.—Tolsi, tolse, tòlsero.
Future—Toglierò, toglierai, etc., and *torrò, torrai,* etc.
Imperat.—Togli, tolga, togliamo, togliete, tòlgano.
Subj. Pres.—Tolga, tolga, tolga, togliamo, togliate, tólgano.
Condit.—Toglierei, toglieresti, etc., and *torrei, torresti,* etc.
Past Part.—Tolto.

Torcere, to twist
Past Def.—Torsi, torse, tòrsero.
Past Part.—Torto.

Tradurre (*tradùcere*), to translate [see *addùrre,* page 5082]

Trarre (old form: *tràere*), to draw
Ind. Pres.—Traggo, trai, trae (*traggiamo*), *traete, tràggono.*
Past Def.—Trassi, traesti, trasse, traemmo, traeste, tràssero.
Future—Trarrò, trarrai, trarrà, etc.
Imperat.—Trai, tragga (*traiamo*), *traete, tràggano*
Subj. Pres.—Tragga, tragga, tragga (*tragghiamo*) (*tragghiate*), *tràggano.*
Subj. Imperf.—Traessi, etc.
Past Part.—Tratto.
Conjugate like *tràrre : contràrre,* to contract; *detràrre,* to detract; *attràrre,* to attract; *sottràrre,* to subtract; *ritràrre,* to draw out; *protràrre,* to protract; *distràrre,* to distract.

Ungere, to anoint
Past Def.—Unsi, unse, ùnsero.
Past Part.—Unto.

Vincere, to vanquish
Past Def.—Vinsi, vinse, vìnsero
Past Part.—Vinto.
Conjugate like *vìncere : convìncere,* to convince.

Vivere, to live
Past Def.—Vissi, visse, vìssero.
Future.—Vivrò, vivrai, etc.
Condit.—Vivrei, vivresti, etc.
Past Part.—Vissuto (*vivuto*).
Conjugate like *vìvere : sopravvìvere,* to survive; *rivìvere,* to live again; *convìvere,* to live together.

Volgere, to turn
Past Def.—Volsi, volse, vòlsero.
Past Part.—Vòlto.
Conjugate like *vòlgere : rivòlgere,* to turn; *rivòlgersi,* to apply; *sconvòlgere,* to overturn; *svòlgere,* to display, to unfold; *invòlgere,* to wrap up, to infold; *travòlgere,* to confuse, to roll over.

Exercise LIII.

1. Dàtemi un fiammìfero, per piacere: il mio sìgaro si è spento. 2. Non lasciate spègnere il fuoco, perchè ritorneremo a casa presto. 3. Il nemico è stato respinto, ma con gravi perdite dei nostri. 4. Sono convinto che le cose stanno come lei dice. 5. Le darò un interessantìssimo romanzo tradotto dall'inglese. 6. Che cosa mi consìglia, di tradurre dall'italiano in inglese o dall'inglese in italiano? 7. Esse si conòbbero tre anni fa a Firenze, e dall'ora in poi (*since then*) sono sempre vissute insieme. 8. L'affare pareva quasi concluso, ma all'ultim'ora sono sorte tali e tante difficoltà, da tògliermi ogni speranza. 9. Questa è una bella occasione per lui, vedremo se questa volta saprà trarne profitto. 10. Egli è andato in Amèrica, attràttovi dalla speranza di gran guadagni. 11. Quel mio amico che riuscì a vìncere una immensa fortuna a Monte-Carlo ha finito per pèrdere fino all'ùltimo soldo. 12. "Questa è la fàvola" disse il vècchio, scotendo il capo, "traètene voi la morale."

Conversazione

Abbia pazienza, signore; due minuti e sono a sua disposizione.
Non posso aspettare di più (*any longer*), perchè sono già in ritardo d'un quarto d'ora.
Perchè non me lo ha detto prima?
Me n'ero dimenticato.
Se incontro il suo amico, cosa devo dirgli?
Gli dica che ha torto di èssere in còllera con me.
Quanta gente! non credo che ci sarà posto.
Il teatro è abbastanza grande, c'è posto per tutti.
E suo fratello, perchè non è venuto con lei?
Perchè aveva qualche cosa da fare, ma verrà più tardi.
Resterà a cena (*supper*) con noi dopo lo spettàcolo?
Con piacere.
Buona sera, signore; e gràzie della bella compagnia.

Key to Exercise LI.

1. After only two hours' fighting, the enemy was completely defeated. 2. The train from Paris has arrived forty minutes late. 3. The two sides of the river are joined by a wooden bridge.

4. Mr. B. has been elected a member of Parliament with eight hundred votes out of a thousand. 5. Where have you put my portrait? 6. You look as if you had been crying. What has happened? 7. I never should have supposed such a thing. 8. If you have read the book I lent you, return it to me. 9. I bet that this time you will lose. 10. I have promised my father to be more diligent, and he has permitted me to go out.

Continued

FRENCH Continued from page 5514 **By Louis A. Barbé, B.A.**

ADJECTIVES

I. Agreement of Adjectives

1. The adjective agrees in gender and number with the noun or pronoun to which it refers: *Les beaux arbres*, the beautiful trees; *les belles fleurs*, the beautiful flowers.

2. *Vous* very frequently and *nous* sometimes refer to one person only, and in that case adjectives in agreement with them must be in the singular: *Vous êtes obligé de ne pas laisser mourir un camarade sans secours*, You are obliged not to allow a comrade to die without help.

3. When an adjective refers to more than one noun, it must be in the plural number: *Le roi et le berger sont égaux après la mort*, The king and the shepherd are equal after death.

4. If the nouns are of different gender the adjective must be masculine and plural: *Chacun travaillait comme s'il avait sa vie et son bonheur attachés au succès*, Each one worked as if he had his life and his happiness depending on success.

5. When an adjective referring to nouns of different gender has different endings for masculine and feminine, the masculine noun should be placed immediately before the adjective: *Cette dame est mise avec une élégance et un goût parfaits*, That lady is dressed with perfect elegance and taste. There would be a harshness of sound if the feminine noun *élégance* and the masculine adjective *parfaits* were brought close together.

6. An adjective though placed after several nouns, agrees with the last of them only if (*a*) they are practically synonymous; (*b*) if they form a climax; or (*c*) if the last of them sums up all the others: *L'aigle fend les airs avec une vigueur, une vitesse, une rapidité prodigieuse*, The eagle cleaves the air with prodigious vigour, speed, and rapidity. In a construction of this kind, the use of the conjunction *et* should be avoided.

7. An adjective occurring after two nouns joined by *ou* must be singular or plural, according as it is intended to qualify only the latter, or both of them: *Les colonnes des maisons se construisent en fer ou en pierre très dure*, The pillars of houses are made of iron or of very hard stone. *Les Lapons se nourrissent de chair ou de poisson crus*, The Laplanders feed on raw flesh or raw fish.

8. When an adjective comes after two nouns joined by *ainsi que, de même que, comme*, as, *aussi bien que*, as well as, *plutôt que*, rather than, *non plus que*, no more than, it agrees with the first only: *La panthère, comme le lion, est carnassière*, the panther, like the lion, is carnivorous.

9. Strictly speaking, adjectives cannot influence a noun, and it is not correct to say *les langues anglaise et française*, the French and English languages. We should say, either, *la langue anglaise et la langue française*, or, *la langue anglaise et la française*. Many writers, however, have preferred the construction which, if not absolutely grammatical, is more concise without being in any way ambiguous.

10. When *avoir l'air* means "to have an air," the adjective agrees with air: *Cette dame a l'air fier et hautain, cependant elle est très affable et très prévenante*, That lady has a proud and haughty air, nevertheless she is very affable and very obliging. But when the meaning of *avoir l'air* is "to seem," "to appear," the adjective agrees with the subject of the verb: *Cette dame à l'air bien malheureuse*, That lady seems very unhappy. When *avoir l'air* is used in connection with inanimate objects the adjective always agrees with the subject of the verb: *Cette maison a l'air solidement construite*, That house looks strongly built.

11. The adjective *nu*, bare, naked, agrees with the noun if it comes after it. When it comes before it, it is joined to it by a hyphen and remains invariable: *Diogène marchait pieds nus et couchait dans un tonneau*, Diogenes walked bare-footed and slept in a tub. *Les mendiants vont nu-pieds et les courtisans nu-tête*, Beggars go about bare-footed and courtiers bare-headed.

12. When *demi* (half) precedes a noun, and is joined to it by a hyphen, it is always invariable. If it follows a noun, it agrees with it in gender, but is always in the singular number: *On ne gouverne pas une nation avec des demi-mesures*, A nation is not governed with half measures. *La séance a duré deux heures et demie*, The sitting lasted two hours and a half.

13. *Feu* (late) agrees with the noun if it immediately precedes it, but remains invariable if it is separated from it by an article or a possessive. It is also invariable before a proper noun: *Votre feue mère était aimée et estimée de tous ceux qui la connaissaient*, Your late mother was loved and respected by all who knew her. *Feu votre tante et moi naquîmes le même jour*, Your late aunt and I were born on the same day.

14. *Franc*, in the expression *franc de port* (post-paid, carriage paid), agrees with the noun which precedes it. It remains invariable when the expression precedes the noun: *Vous recevrez franc de port toutes les lettres que je vous adresserai*, You will receive post-paid all the letters I shall address to you (send you). *Ces lettres sont franches de port*, Those letters are prepaid.

15. In the expression *se faire fort* (to undertake), *fort* is always invariable: *Ces dames se font fort d'obtenir le consentement de leurs maris*, Those ladies undertake to obtain the consent of their husbands.

16. Compound adjectives consisting of two adjectives or of an adjective and a past participle, require both their components to agree with the qualified noun: *des pommes aigres-douces*, sourish apples.

17. In the compounds *mort-né* (still-born), *nouveau-né* (new-born), and *court-vêtu* (short-coated), the first of the two components is always invariable: *des enfants nouveau-nés*, new-born infants.

18. In the compound *frais-cueilli* (freshly-gathered), both components agree with the qualified noun: *des fleurs fraîches-cueillies*, freshly-gathered flowers.

19. Nouns used as adjectives of colour are usually invariable, such as *paille* (straw-coloured), *noisette* (hazel-coloured), etc. But, *rose* (pink), *cramoisi* (crimson), *pourpre* (purple), and *écarlate* (scarlet) are dealt with as adjectives: *des chapeaux roses*, pink bonnets.

20. When colour is expressed by a combination of two adjectives, both of them remain invariable: *Elle a les cheveux châtain clair et les yeux bleu foncé*, She has light auburn hair and dark blu eyes.

II. Comparison of Adjectives

1. The comparatives of equality, of superiority, and of inferiority are respectively formed by means of *aussi . . . que*, *plus . . . que*, and *moins . . . que*: *Il est aussi modeste que vaillant*, He is as modest as he is brave; *Les remèdes sont plus lents que les maux*, Remedies are slower than diseases; *La Seine est moins large que le Rhin*, The Seine is less broad than the Rhine.

2. In negative sentences *aussi* may be replaced by *si*: *Le fils n'est pas si grand que le père*, The son is not so tall as the father.

3. Sometimes *aussi* or *si* is omitted, and in that case *comme* is used instead of *que*: *Il est entêté comme un mulet*, He is as stubborn as a mule.

4. When the comparison is between two infinitives, the first of them is preceded by either *à* or *de*, and the same preposition is repeated after *que*: *Il est plus facile de donner des conseils que de les suivre*, It is easier to give advice than to follow it; *Je suis plus disposé à le plaindre qu'à le blâmer*, I am more inclined to pity him than to blame him.

5. When the second part of a comparison of superiority or of inferiority is followed by a verb in a finite tense, that verb takes *ne* before it unless it be preceded by a negative verb: *Les sciences et les arts sont plus cultivés aujourd'hui qu'ils ne l'ont jamais été*, The sciences and the arts are more cultivated now than they have ever been; *Après l'invention de la poudre, les batailles devinrent beaucoup moins sanglantes qu'elles ne l'avaient été auparavant*, After the invention of gunpowder, battles became much less sanguinary than they had previously been.

6. "More and more" is expressed by *de plus en plus*, and "less and less" by *de moins en moins*: *Il devient tous les jours de plus en plus exigeant*; *il est de moins en moins facile à contenter*, He is becoming more and more exacting every day; he is less and less easy to satisfy.

7. "All the more" is translated by *d'autant plus*: *Ce contretemps était d'autant plus fâcheux qu'il nous faisait manquer la correspondance*, This untoward accident was all the more disagreeable that it made us miss the connection.

8. The definite article which forms a part of the superlative agrees with the qualified noun when the superlative is relative, that is, when it implies a comparison with other persons or things: *Le désespoir est le pire de tous les maux*, Despair is the worst of all evils.

9. When there is no comparison with other persons or things, but only of the various stages of the same quality in the same person or thing, the article is always *le*: *La lune n'est pas aussi éloignée de la terre que le soleil, lors même qu'elle en est le plus éloignée*, The moon is not so far distant from the earth as is the sun, even when she is most distant from it.

It is to be noted that this distinction between the relative superlative and the absolute superlative is indicated in English by the use or the omission of the article "the."

III. Position of Adjectives

1. When one noun is qualified by two or more adjectives, each of them follows its own rule (as given on page 1339) in regard to position: *Voilà une jolie petite maison*, There is a pretty little house; *une petite maison blanche*, a little white house.

2. If the adjectives are joined by a conjunction and one of them regularly follows the noun, then both of them must be placed after it: *Une belle femme*, a beautiful woman; *une femme riche*, a rich woman; *une femme belle et riche*, a woman beautiful and rich.

3. A certain number of adjectives have different meanings according as they precede or follow the qualified substantive. It will be seen from the following list of the most important of them that the double meaning is possible in connection with special substantives only:

ANCIEN: *Un ancien élève*, a former pupil; *l'histoire ancienne*, ancient history.

BON: *Un bon homme* (frequently written *bonhomme*), a simple man, an old man; *un homme bon*, a kind, charitable man.

BRAVE: *Un brave homme*, a worthy man; *un homme brave*, a brave man.

CERTAIN: *Une certaine chose*, a certain thing; *une chose certaine*, something about which there is no doubt.

CHER: *Mon cher ami*, my dear friend; *des objets chers*, expensive articles.

COMMUN: *La commune voix*, the unanimous voice; *une voix commune*, a vulgar voice, an ordinary voice.

CRUEL: *Un cruel homme*, a disagreeable man, a bore; *un homme cruel*, a cruel, heartless man.

DERNIER: *Le dernier mois de l'année*, the last month of the year; *la semaine dernière*, last week.

DIFFÉRENT: *Différentes raisons*, different (several) reasons; *des raisons différentes*, different (not the same) reasons.

DIGNE: *Une digne femme*, a worthy woman; *une femme digne*, a dignified woman.

DIVERS: *Diverses personnes*, divers (several) persons; *des opinions diverses*, conflicting opinions.

FAMEUX: *Un auteur fameux*, a famous author; *un fameux imbécile*, a precious fool.

FAUX: *Une fausse clef*, a false key; *une clef fausse*, a wrong key.

FIER: *Un air fier*, a proud look; *un fier dîner*, a capital dinner.

FORT: *Une forte femme*, a stout woman; *une femme forte*, a strong-minded woman.

FRANC: *C'est un homme franc*, He is a plain-spoken man; *C'est un franc coquin*, He is a thorough scoundrel.

FURIEUX: *Un fou furieux*, a raving madman; *un furieux menteur*, an awful liar.

GALANT: *Un galant homme*, a man of honour, a gentleman; *un homme galant*, a courteous man, a ladies' man.

GRAND: *Un grand homme*, a great man; *un homme grand*, a tall man.

HAUT: *La haute mer*, the high sea; *la mer haute*, the high tide.

HONNÊTE: *Un honnête homme*, an honest man; *un homme honnête*, a civil man.

JEUNE: *Un jeune homme*, a young man; *un homme jeune*, a man still young.

MAIGRE: *Un maigre dîner*, a meagre dinner; *un repas maigre*, a lenten meal (without flesh-meat).

MALHONNÊTE: *C'est un malhonnête homme*, He is a dishonest man; *un enfant malhonnête*, a rude, uncivil child.

Mauvais : *Il a l'air mauvais*, He has an evil look ; *Il a mauvais air*, He has a disreputable appearance.

Méchant : *Un méchant poète*, a wretched poet, a poetaster ; *Il a la mine méchante*, He has an ill-natured, spiteful look.

Mort : *Morte-eau*, neap-tide ; *eau morte*, stagnant water.

Nouveau : *Il porte un nouvel habit aujourd'hui*, He is wearing a new (different) coat to-day ; *Je n'aime pas les chapeaux nouveaux*, I don't like the new-fashioned hats.

Parfait : *C'est un parfait honnête homme*, He is a thorough gentleman ; *C'est un acteur parfait*, He is a perfect actor.

Pauvre : *C'est un pauvre auteur*, He is an author of no great merit ; *C'est un auteur pauvre*, He is a needy author.

Petit : *Un petit homme*, a man of low stature ; *un homme petit*, a despicable man.

Plaisant : *Un plaisant individu*, a ridiculous fellow ; *un homme plaisant*, an amusing man.

Premier : *Nos premiers parents*, our first parents; *matière première*, raw material.

Propre : *Il a écrit cette lettre de sa propre main*, He has written that letter with his own hand ; *Cet enfant n'a jamais les mains propres*, That child never has clean hands.

Pur : *C'est la pure vérité*, It is the plain truth ; *du vin pur*, pure wine (without water).

Seul : *Un seul homme*, a single man ; *un homme seul*, a solitary man.

Simple : *Un simple soldat*, a private ; *un homme simple*, an unpretending man.

Triste : *J'ai fait un triste repas*, I have made a sorry meal ; *Il a l'air triste*, He looks sad.

Véritable : *C'est un véritable fléau*, It is a downright plague ; *C'est une histoire véritable*, It is a true story.

Vrai : *Un vrai coquin*, a thorough knave ; *C'est une histoire vraie que je vous raconte*, It is a true story I am telling you.

IV. Complement of Adjectives

Adjectives are frequently followed by a complement to which they are joined by a preposition. The principal prepositions used for this purpose are *à*, *de*, *en*, *envers* and *pour*.

1. *À*. The preposition *à* is commonly used after adjectives denoting habit, fitness, resemblance, comparison, conformity, inclination, advantage, utility, necessity, and their opposites. Among them are :

adroit, clever at	*fort*, clever at
ardent, keen for	*hardi*, bold in
assidu, assiduous in	*impropre*, unfit for
bon, good, fit for	*nécessaire*, necessary for
exact, exact in	*propre*, fit for
semblable, similar to	

2. De. The preposition *de* is commonly used after adjectives denoting separation, cause, origin, supply, satisfaction, want, desire. Among them are :

ami, friendly to	*fou*, doting on
atteint, struck by, seized with	*furieux*, furious at
	glacé, chilled with
débarrassé, free from, rid of	*heureux*, delighted with
désolé, distressed at	*inquiet*, anxious about
doué, endowed with	*nourri*, fed on
empréssé, eager to	*paré*, adorned with
ennemi, hostile to	*pourvu*, provided with
étincelant, sparkling with	*ravi*, delighted with
fâché, sorry for	*stupéfait*, amazed at
fort, relying on, confident in	*triste*, sad at

3. En. Adjectives denoting proficiency, abundance, are frequently followed by *en* : *abondant*, abounding in ; *expert*, expert in ; *riche*, rich in.

4. Pour, Envers. Adjectives denoting feeling, behaviour, disposition towards, are followed either by *pour* or by *envers* :

(*a*) *Envers* :

affable, affable towards (to)	*généreux*, generous towards
amical, friendly to	*indulgent*, indulgent towards
bon, kind to	
charitable, charitable to	*ingrat*, ungrateful towards
cruel, cruel to	*injuste*, unjust towards
dur, harsh towards	*juste*, just to (towards)

(*b*) *Pour* :

affable, affable to	*indulgent*, indulgent for
bon, kind to	*injurieux*, insulting to (for)
bienveillant, friendly towards	*nécessaire*, necessary for
	sévère, severe to
commode, convenient for	*utile*, useful for

PRONOUNS

Personal Pronouns

1. Pronouns can take the place of determinate nouns only—that is to say, of nouns preceded by an article, a possessive, or a demonstrative. It is consequently incorrect to say : *Il nous a fait réponse, et la voici*, because the pronoun *la* stands for *réponse*, which is indeterminate. It has no independent value as a substantive, but simply helps to make up the locution *faire réponse—répondre*.

The correct construction is : *Il nous a fait parvenir sa réponse, et la voici*, He has forwarded us his answer, and here it is.

2. The relation between pronoun and noun must always be expressed in such a way as to leave no room for ambiguity. It is consequently incorrect to say : *Molière a surpassé Plaute dans tout se qu'il a fait de meilleur*. In this sentence it is doubtful whether the pronoun *il* refers to *Molière* or to *Plaute*. The ambiguity may be removed by saying : *Molière a surpassé Plaute dans tout ce que celui-ci a fait de meilleur*, Molière has excelled Plautus in all the best that the latter has produced.

3. When the pronoun *on* occurs several times in the same sentence it must always relate to the same person ; thus, it is correct to say : *On ne craint pas la mort quand on a assez bien vécu pour n'en pas craindre les suites*, One does not fear death when one has lived well enough not to fear what follows it. But it is incorrect to say : *La civilité exige qu'on écoute avec attention ce qu'on nous dit.*

The first *on* is evidently equivalent to *nous*, and must be replaced by it : *La civilité exige que nous écoutions avec attention ce qu'on nous dit*, Civility requires that we should listen with attention to what one says to us.

4. *On*, being an indefinite personal pronoun, may stand for either the first, the second, or the third person, singular or plural. In the following quotation from Molière, *on* is used for *je* :

Allez, vous êtes fou dans vos transports jaloux,
Et ne méritez pas l'amour qu'on a pour vous,
Go, you are mad in your fits of jealousy,
And do not deserve the love which one has (I have) for you.

5. The verb of which *on* is the subject is always in the third person singular. Adjectives in agreement with it are regularly masculine and singular.

When it is clear from the context that *on* refers to a feminine subject, the adjective is also feminine : *On devient forte alors qu'on devient mère*, One

(a woman) becomes strong when one (she) becomes a mother.

6. The adjective will also be plural if it is obvious that the subject *on*, though formally singular, is essentially plural: *En France, on est tous égaux devant la loi.* English will not admit of a literal translation of this peculiar construction. We must say: In France, all are equal before the law.

7. *Lui* is both masculine and feminine when it is the indirect object or dative of the conjunctive form of the personal pronoun; otherwise it is exclusively masculine. Thus, *Je lui ai parlé* means both "I have spoken to him" and "I have spoken to her." But *c'est à lui que j'ai parlé* can mean only: It is to him I have spoken.

8. *Lui* preceded by a preposition refers to persons only. When the reference is to inanimate objects, *y* or *en* is used. Thus, in speaking of a tree, we may not say: *Ne montez pas sur lui,* but: *N'y montez pas,* Do not climb on it.

9. The same remarks apply to *elle* when it is in the disjunctive form. Thus, in speaking of a science or of a profession, we may not say: *Il s'est adonné à elle,* but *Il s'y est adonné,* He has devoted himself to it.

10. With the prepositions *après,* after, *avec,* with, *contre,* against, of which the meaning cannot be expressed by *y* or *en,* both *lui* and *elle* may be used with reference to inanimate objects:

Quand cette rivière (*ce fleuve*) *déborde, elle* (*il*) *entraîne avec elle* (*lui*) *tout ce qu'elle* (*il*) *rencontre ; elle* (*il*) *ne laisse rien après elle* (*lui*), When this river overflows, it carries away with it all it meets; it leaves nothing after it.

Continued

ESPERANTO

Continued from page 5518

By Harald Clegg

VERBS

Conditional Mood

The conditional mood of the verb is formed by adding *us* to the root.

Example: *Mi irus kun vi, se mi povus,* I would go with you if I could; *Mi ne skribus tion, se mi estus vi,* I would not write that if I were you.

In the use of the conditional mood there is always present a sense of doubt, or an implication of denial, which is shown either by the actual presence of an "if" (*se*) or by an implied condition.

Example: *Ĉu vi pensas, ke li kredus tion?* Do you think he would believe that? (if he heard it).

It must not, however, be overlooked that *se* does not necessarily always contain an element of doubt. The sentence *Se ĝi estis tiel* suggests the admission of the speaker that, in fact, the case was so, but *Se ĝi estus tiel* implies an assertion that it was not so. The correct use of Esperanto is always in accordance with the logical meaning of a sentence.

The conditional mood can also be used to moderate the force of a statement, thus substituting a polite suggestion.

Example: *Mi volus paroli kun vi,* I want (should like) to speak to you (if you are willing); *Li dankus vin por via helpo,* He would thank you for your help (if you would consent to give it).

NUMERALS

Multiple Numbers. Multiple numbers are formed regularly from the cardinals by the addition of the suffix *obl,* to which, of course, the characteristic signs of the noun, adjective, and adverb may be added.

Example: *Unuobla,* single; *duoble,* doubly; *trioble,* threefold, trebly.

Fractional Numbers. Fractional numbers may be constructed from the cardinals by adding the suffix *on,* and they may be used as nouns, adjectives, or adverbs by adding the final *o, a,* or *e.*

Examples: *Duono,* a half, *dekona parto,* a tenth part; *sepokonoj,* seven eighths; *Tri estas la centona parto de tricent,* Three is one hundredth of three hundred.

Distributives. Distributives indicating proportion are shown by placing the preposition *po* (at the rate of) before a cardinal number.

Example: *Oni pagas al soldatoj po unu ŝilingo ĉiutage,* Soldiers are paid at the rate of one shilling per day; *Mi vendis la ovojn po ses pencoj por kvar,* I sold the eggs at sixpence for four.

CONJUNCTIONS

Duplication. Some of the Esperanto conjunctions conveniently lend themselves to the process of being duplicated where in English we use two distinct words, such as neither, nor.

Example: *Aŭ . . . , aŭ* (either . . . or). *Vi devas, aŭ silenti, aŭ foriri,* You must either be silent or go away; *Ĉu . . . ĉu* (whether . . . or), *Mi estos kontenta ĉu li venas, ĉu ŝi,* I shall be satisfied whether he comes or she; *Jen . . . jen* (sometimes . . . sometimes), *Jen ŝi kantas, jen ŝi dancas,* Sometimes she sings, sometimes she dances; *Nek . . . nek* (neither . . . nor), *Mi nek movos, nek unu vorton parolos,* I will not stir, nor speak a word; *Ju pli . . . des pli* (the more . . . the more), *Ju pli ni havas des pli ni dezirus,* The more we have the more we want.

VOCABULARY

Eben', even, level
egal', equal
ekzempl', example
eminent', eminent
envi', envy
estim', esteem
favor', favour
firm', firm
flav', yellow
fromaĝ', cheese
frukt', fruit
glaci', ice
ĝeneral', general (adj.)
herb', grass
ho! oh!
insult', abuse, insult
ja, indeed, in fact
ĵus, just, at the very moment
kap', head
klas', class, sort
komun', common
koncern', concern
kondiĉ', condition, stipulation
krajon', pencil
kuir', cook (v. t.)
kuŝ', lie (down)
leĝ', law
lev', lift, raise
liter', letter (alphabet)
lud', play
makul', stain, spot
mejl', mile
mensog', lie (subst.)
mus', mouse
ord', order, regularity
pacienc', patience
parenc', relation
perfekt', perfect
pren', take
pret', ready
proksim', near, next
propr', own, one's own
pruv', prove, demonstrate
pur', pure, clean
rakont', tell, relate
rimark', remark, notice
sek', dry
son', sound
spez', spend (*elspezo,* expense; *enspezo,* revenue)

Exercise XI.

If you lied I should despise you. The pencil now lies upon the bed, where you just put it. Oh, my dear brother-in-law, would you insult

your own relation? She is ten times richer than you. The more I know that the more I envy her. He (that one) who would be happy ought to have patience. He can run seven and five-eighths miles in the hour. Every letter in the Esperanto alphabet has a separate sound. I should approve; I should, in fact, be perfectly satisfied if you would consent to accept the advice of my eminent friend. Eleven times twelve make one hundred and thirty-two, which is the fourth part of five hundred and twenty-eight. She bought three-quarters of a pound of fruit and an equal quantity of yellow cheese. There is a dirty stain upon that book. Would you be ready to meet me if I waited half an hour? The ice is firm and level. He proved to me that the laws of this country are just, although he confessed that one needs a lot of patience. Last night we went to the theatre and there we quickly spent all our money. That which concerns me is not necessarily always your affair. She related to me all that I wanted to hear. If I read this book each day at the rate of fifty pages, I could send it back to you next week.

KEY TO EXERCISE X.

Kiam vi vidis lin kun tia stranga persono, kial vi ne parolis al mi? Kiuj estas la kvar sezonoj de la jaro? Printempo, somero, aŭtuno, vintro. Tiuj ĉi viroj, kies konduton mi malaprobis, subite min atakis kvinope. Kioma estas la hodiaŭa dato? Ĉu vi povas diveni mian aĝon? Kien vi ĝin ĵetis? La ŝtono falis tien. Tio certe estas justa. Mi neniam renkontis viajn kolegojn pri kiuj vi parolas. Kiom kostas tiu ĉi malnova libro? Larmoj falis unu post la alia el ŝiaj okuloj, kiam ŝi aŭdis la kialon. Mi neniam povos pardoni al ili iliajn kulpojn, sed kiam ilia konduto gajnos mian aprobon, tiam mi ilin laŭdos. Mia memoro ĉiam min iom trompas. La hundo, kiu laŭte bojas, neniam mordas. Ĉiuj nacioj progresas; unuj rapide, aliaj malrapide. La akvo tie ĉi estas iom profunda. Tio estas sufiĉa. Ni devas labori por gajni tion, kion havi estas necese—tio estas, mono. Mi nenie, kaj neniam, parolis tiajn parolojn. Mi havas tiom da zorgoj, kiom vi. Kial vi ne aŭskultis lin? Kiam li aŭdis mian voĉon, li haltis, kaj tiam li ial subite kuris en la domon. Mi volas sci tion, kion li diris al vi pri tiaj publikaj aferoj. Jen estas ies ganto. Kies ĝi estas?

Continued

GREEK

Continued from page 5520

By G. K. Hibbert, M.A.

SECTION I. ACCIDENCE

Third Declension Nouns—continued

So far we have dealt only with nouns of this declension with mute or liquid stems. We now come to those whose stems end in Σ (S), or in a vowel or diphthong.

1. Nouns of this declension in ης and ος (the latter being neuter) are thus declined, contraction taking place whenever the ε of the stem precedes a vowel.

ἡ τριήρης, trireme; τὸ γένος, race, stock.

Singular

Nom.	τριήρης	γένος
Voc.	τριῆρες	γένος
Acc.	τριήρη (τριήρεα)	γένος
Gen.	τριήρους (-εος)	γένους (-εος)
Dat.	τριήρει (-εϊ)	γένει (-εϊ)

Dual

N., V., A.	τριήρη	γένη
Gen., Dat.	τριήροιν	γενοῖν

Plural

Nom., Voc.	τριήρεις (-εες)	γένη (γένεα)
Acc.	τριήρεις (-εας)	γένη
Gen.	τριήρων	γενῶν or γενέων
Dat.	τριήρεσι	γένεσι

Like τριήρης decline Σωκράτης, Socrates; and Δημοσθένης, Demosthenes (in the singular only). Like γένος decline τὸ κάλλος, beauty; τὸ ὄρος, mountain; and τὸ θέρος, summer.

2. Nouns in ις, ι, υς, υ, and ευς are thus declined (ι and υ are neuter endings):

ἡ πόλις, city; τὸ ἄστυ, town; ὁ πῆχυς, fore-arm, cubit; ὁ βασιλεύς, king.

Singular

N.	πόλις	ἄστυ	πῆχυς	βασιλεύς
V.	πόλι	ἄστυ	πῆχυ	βασιλεῦ
A.	πόλιν	ἄστυ	πῆχυν	βασιλέα
G.	πόλεως	ἄστεος or εως	πήχεως	βασιλέως
D.	πόλει	ἄστει	πήχει	βασιλεῖ

Dual

N., V., A.	πόλεε	ἄστεε	πήχεε	βασιλέε
G., D.	πολέοιν	ἀστέοιν	πηχέοιν	βασιλέοιν

Plural

N., V.	πόλεις (-εες)	ἄστη (-εα)	πήχεις	βασιλεῖς
A.	πόλεις (-εας)	ἄστη (-εα)	πήχεις	βασιλέας
G.	πόλεων	ἀστέων	πήχεων	βασιλέων
D.	πόλεσι	ἄστεσι	πήχεσι	βασιλεῦσι

NOTE. Nouns in ι (as τὸ σίναπι, mustard) are declined like ἄστυ. Most nouns in υς retain υ and are regular—*e.g.*, ἰχθύς, fish; *gen.*, ἰχθύος; *dat.*, ἰχθύϊ; *nom. pl.*, ἰχθύες; *dat. pl.*, ἰχθύσι.

3. Nouns in ους and αυς are thus declined:

ὁ, ἡ βοῦς, ox, cow; ἡ γραῦς, old woman; ἡ ναῦς, ship.

Singular

Nom.	βοῦς	γραῦς	ναῦς
Voc.	βοῦ	γραῦ	ναῦ
Acc.	βοῦν	γραῦν	ναῦν
Gen.	βοός	γραός	νεώς
Dat.	βοΐ	γραΐ	νηΐ

	Dual		
N., V., A.	βόε	γρᾶε	νῆε
Gen., Dat.	βοοῖν	γραοῖν	νεοῖν
	Plural		
N., V.	βόες	γρᾶες	νῆες
Acc.	βοῦς	γραῦς	ναῦς
Gen.	βοῶν	γραῶν	νεῶν
Dat.	βουσί	γραυσί	ναυσί

NOTE. ναῦς is very irregular, and has also acc. sing., νῆα or νέα; gen., νηός or νεός; etc.

4. Nouns in ας, genitive αος (neuter), are thus declined, contraction taking place when the α of the stem is followed by a vowel:

	Singular	*Dual*	*Plural*
Nom. *Voc.* *Acc.*	γέρας, prize	(γέρα)	γέρα
Gen.	γέρως (-αος)	(γερῷν)	γερῶν
Dat.	γέρᾳ	(γερῷν)	γέρασι

κέρας, κέρατος, horn, is sometimes declined regularly (κέρας, κέρατος, κεράτι, etc.), sometimes like γέρας (κέρως, κέρᾳ, etc.).

5. There are a few nouns in ώ and ώς, declined as follows (the dual and plural are rare):

Singular		*Dual*		*Plural*	
N.	ἠχώ, echo	*N.* *V.* *A.*	ἠχώ	*N.* *V.*	ἠχοί
V.	ἠχοῖ			*A.*	ἠχούς
A.	ἠχώ				
G.	ἠχοῦς	*G.* *D.*	ἠχοῖν	*G.*	ἠχῶν
D.	ἠχοῖ			*D.*	ἠχοῖς

ἡ αἰδώς, shame; accusative, αἰδῶ; genitive, αἰδοῦς; dative, αἰδοῖ. No dual or plural.

ὁ ἥρως, hero, has genitive ἥρωος, and is regular (accusative, ἥρωα; dative, ἥρωϊ, etc.).

6. Some nouns in ηρ, as ὁ πατήρ, father; ἡ μήτηρ, mother; ἡ θυγάτηρ, daughter (genitive -ερος), are shortened by dropping the ε in the genitive and dative singular; also in the dative plural they change ερ into ρα before σι. Thus:

Singular		*Dual*		*Plural*	
N	πατήρ	*N.* *V.* *A.*	πατέρε	*N.* *V.*	πατέρες
V.	πάτερ			*A.*	πατέρας
A.	πατέρα				
G.	πατρός	*G.* *D.*	πατέροιν	*G.*	πατέρων
D.	πατρί			*D.*	πατράσι

Adjectives. *First and third declensions combined.* Most of these end either in υς, εια, υ, or in εις, εσσα, εν—as, ταχύς, ταχεῖα, ταχύ, swift; χαρίεις, χαρίεσσα, χαρίεν, graceful.

	Masculine	*Feminine*	*Neuter*
	Singular		
Nom.	ταχύς	ταχεῖα	ταχύ
Voc.	ταχύ	ταχεῖα	ταχύ
Acc.	ταχύν	ταχεῖαν	ταχύ
Gen.	ταχέος	ταχείας	ταχέος
Dat.	ταχεῖ	ταχείᾳ	ταχεῖ
	Dual		
N., V., A.	ταχέε	ταχεία	ταχέε
Gen., Dat.	ταχέοιν	ταχείαιν	ταχέοιν
	Plural		
N., V.	ταχεῖς	ταχεῖαι	ταχέα
Acc.	ταχεῖς	ταχείας	ταχέα
Gen.	ταχέων	ταχειῶν	ταχέων
Dat.	ταχέσι	ταχείαις	ταχέσι

	Masculine	*Feminine*	*Neuter*
	Singular		
Nom.	χαρίεις	χαρίεσσα	χαρίεν
Voc.	χαρίεν	χαρίεσσα	χαρίεν
Acc.	χαρίεντα	χαρίεσσαν	χαρίεν
Gen.	χαρίεντος	χαριέσσης	χαρίεντος
Dat.	χαρίεντι	χαριέσσῃ	χαρίεντι
	Dual		
N., V., A.	χαρίεντε	χαριέσσα	χαρίεντε
Gen., Dat.	χαριέντοιν	χαριέσσαιν	χαριέντοιν
	Plural		
N., V.	χαρίεντες	χαρίεσσαι	χαρίεντα
Acc.	χαρίεντας	χαριέσσας	χαρίεντα
Gen.	χαριέντων	χαριεσσῶν	χαριέντων
Dat.	χαρίεσι	χαριέσσαις	χαρίεσι

NOTE. The feminine of ταχύς is declined like οἰκία, and the feminine of χαρίεις like θάλασσα.

There are three adjectives ending in ας: πᾶς, πᾶσα, πᾶν, all; μέλας, μέλαινα, μέλαν, black; and τάλας, τάλαινα, τάλαν, wretched. πᾶς and μέλας are thus declined:

	Masculine	*Feminine*	*Neuter*
	Singular		
Nom.	πᾶς	πᾶσα	πᾶν
Acc.	πάντα	πᾶσαν	πᾶν
Gen.	παντός	πάσης	παντός
Dat.	παντί	πάσῃ	παντί
	Plural		
Nom.	πάντες	πᾶσαι	πάντα
Acc.	πάντας	πάσας	πάντα
Gen.	πάντων	πασῶν	πάντων
Dat.	πᾶσι	πάσαις	πᾶσι
	Singular		
Nom.	μέλας	μέλαινα	μέλαν
Voc.	μέλαν	μέλαινα	μέλαν
Acc.	μέλανα	μέλαιναν	μέλαν
Gen.	μέλανος	μελαίνης	μέλανος
Dat.	μέλανι	μελαίνῃ	μέλανι
	Dual		
N., V., A.	μέλανε	μελαίνα	μέλανε
Gen., Dat.	μελάνοιν	μελαίναιν	μελάνοιν
	Plural		
N., V.	μέλανες	μέλαιναι	μέλανα
Acc.	μέλανας	μελαίνας	μέλανα
Gen.	μελάνων	μελαινῶν	μελάνων
Dat.	μέλασι	μελαίναις	μέλασι

NOTE. τάλας is declined like μέλας.

Two Irregular Adjectives. μέγας, great, and πολύς, much, are declined irregularly:

	Masculine	*Feminine*	*Neuter*
	Singular		
Nom.	μέγας	μεγάλη	μέγα
Voc.	(μεγάλε)	μεγάλη	μέγα
Acc.	μέγαν	μεγάλην	μέγα
Gen.	μεγάλου	μεγάλης	μεγάλου
Dat.	μεγάλῳ	μεγάλῃ	μεγάλῳ
	Dual		
N., V., A.	μεγάλω	μεγάλα	μεγάλω
Gen., Dat.	μεγάλοιν	μεγάλαιν	μεγάλοιν

	Plural		
N., V.	μεγάλοι	μεγάλαι	μεγάλα
Acc.	μεγάλους	μεγάλας	μεγάλα
Gen.	μεγάλων	μεγάλων	μεγάλων
Dat.	μεγάλοις	μεγάλαις	μεγάλοις
	Singular		
Nom.	πολύς	πολλή	πολύ
Acc.	πολύν	πολλήν	πολύ
Gen.	πολλοῦ	πολλῆς	πολλοῦ
Dat.	πολλῷ	πολλῇ	πολλῷ
	Plural		
N., V.	πολλοί	πολλαί	πολλά
Acc.	πολλούς	πολλάς	πολλά
Gen.	πολλῶν	πολλῶν	πολλῶν
Dat.	πολλοῖς	πολλαῖς	πολλοῖς

Regular Verb. λύω, I loose.

	Imperfect Indicative.	*Aorist Indic.*
1. *Singular*	ἔλυον, I was loosing,	ἔλυσα, I loosed
2. ,,	ἔλυες *or*	ἔλυσας
3. ,,	ἔλυε(ν) used to loose	ἔλυσε(ν)
2. *Dual*	ἐλύετον	ἐλύσατον
3. ,,	ἐλυέτην	ἐλυσάτην
1. *Plural*	ἐλύομεν	ἐλύσαμεν
2. ,,	ἐλύετε	ἐλύσατε
3. ,,	ἔλυον	ἔλυσαν

NOTES. 1. The ε prefixed to these two tenses is called the *Augment* (literally, *increase*). All the past, or historic, tenses of the indicative mood have some kind of augment. Verbs beginning with a consonant always prefix ε to the stem to form the imperfect and aorist indicative, as λύω, ἔλυον, ἔλυσα; σώζω, ἔσωζον, ἔσωσα. This is called the Syllabic Augment. When the verb begins with a vowel, the augment lengthens the initial vowel, as ἄγω, I lead, ἦγον; ἔχω, I have, εἶχον. This is called the Temporal Augment.

2. The imperfect denotes continued or repeated action; the aorist expresses a completed action in indefinite past time: ἔλυον = I was in the habit of loosing, *or*, I was loosing; ἔλυσα = I loosed.

SECTION II. SYNTAX

RULE 1. A substantive may have another substantive added to explain or describe it; the latter is then said to be in *apposition* to the former, and agrees with it in case—as, Νικίας ὁ στρατηγός, Nicias the general; ὁ υἱός τοῦ Δαρείου, τοῦ Πέρσου, the son of Darius, the Persian.

RULE 2. Words which qualify or describe a noun are usually placed between that noun and its article—as, the vulture's claws, οἱ τοῦ γυπός ὄνυχες; the trees in the island, τὰ ἐν τῇ νήσῳ δένδρα.

RULE 3. πᾶς without the article means *every*—as, πᾶσα πόλις, every city. But with the article πᾶς means *all* or *the whole*—as, πᾶσα ἡ πόλις, all the city; ἡ πᾶσα πόλις, the whole city.

RULE 4. When μέγας or πολύς is used with another adjective, the two adjectives are generally connected by καί—as, The great black bird, ὁ μέγας καὶ μέλας ὄρνις; He saved many poor citizens, ἔσωσε πολλοὺς καὶ πένητας πολίτας.

RULE 5. The article is frequently used with an adverb—as, οἱ πάλαι, the men of old; οἱ ἐκεῖ, the people there; οἱ νῦν, the men of the present day. The noun has here been omitted, the full phrase being οἱ πάλαι ἄνθρωποι, and so on.

RULE 6. In Greek the article is required with nouns denoting a whole class of things—as, Οἱ ἄνθρωποί εἰσι θνητοί, Men are mortal; Οἱ λέοντές εἰσι δεινοί, Lions are terrible.

EXERCISE V.

here, ἐνταῦθα	I make, ποιέω (aorist ἐποίησα)
Cyrus, Κύρος	citadel, ἡ ἀκρόπολις
palace, τὰ βασίλεια (plural)	soul, ἡ ψυχή
park, παράδεισος	I magnify, μεγαλύνω
I hunt, θηρεύω	Lord, Κύριος
from, ἀπὸ (governs gen.)	I rejoice, ἀγαλλιάω (aorist ἠγαλλίασα)
through, διὰ ,,	Saviour σωτήρ, -ῆρος
I flow, ῥέω	good, ἀγαθός, η, ον
source, ἡ πηγή	corrupt, σαπρός, α, ον
Apollo, Ἀπόλλων	fruit, ὁ καρπός
I kill, κτείνω (aorist ἔκτεινα)	evil, πονηρός, α, ον

1. Here Cyrus had a palace (say: there was to Cyrus a palace) and a great park, full of wild beasts. 2. The king used to hunt the wild beasts on horse-back (say: from a horse). 3. Through the park flows the river Maeander (Μαίανδρος), and the sources of the river start from (say: are out of) the palace. 4. It flows through the whole city. 5. The men of old used to say that (ὅτι) Apollo killed Marsyas (Μαρσύας) here. 6. There Xerxes, the king of the Persians, made a citadel and a palace.

7. My soul (say: the soul *of me*, μου) doth magnify (magnifies) the Lord and my spirit hath rejoiced (aorist) in (ἐπι, governing dative) God my Saviour. 8. Every good tree bringeth forth (maketh, ποιέω) good fruit, but the corrupt tree bringeth forth evil fruit (plural).

KEY TO EXERCISE III.

1. τῆς ἀπλῆς κόρης. 2. τῷ ἐχθρῳ στρατιώτῃ. 3. χρυσᾶ δῶρα. 4. τῶν σοφῶν νεανιῶν. 5. τὴν ἄδικον κόρην. 6. τῇ ἀργυρᾷ θαλάσσῃ. 7. ἄλογοι νόμοι. 8. τοῦ σοφοῦ νοῦ. 9. τοῦ χρυσοῦ νεώ. 10. τοὺς ἀπλοῦς κριτάς.

KEY TO EXERCISE IV.

1. ἐν τῇ οἰκίᾳ εἰσὶ παῖς καὶ κόρη. 2. ἡ οἰκία ἐστὶ πλήρης κανῶν, καὶ ἐν τοῖς κανοῖς ἐστιν ᾠά. 3. τὰ ᾠὰ ἦν τοῦ ἵλεω γέροντος δῶρον. 4. ὁ παῖς θαυμάζει τὰ κανᾶ· λύει τὸ ἱμάτιον. 5. ταχέως λύσει κανοῦν. 6. ἡ κόρη ἐστὶ κακὴ καὶ χορεύει χαρᾷ. 7. ἐλπίζει τὰ ᾠά· λέγει ὅτι ὁ χρόνος ἐστὶ μακρός. 8. ἀλλ' ὁ δαίμων ἐστὶν ἄγριος· διώκει τὸν παῖδα καὶ τὴν κόρην. 9. τὸ κανοῦν πίπτει· τὰ ᾠά ἐστι παλαιὰ καὶ ἡ οἰκία οὐκ ἔστι τερπνή. 10. ὁ παῖς καὶ ἡ κόρη τρέχουσι ἐκ τῆς οἰκίας, οἰκτροὶ καὶ σοφοί.

Continued

NOTE.—The next instalment of the SPANISH course will appear in Part **40** of the SELF-EDUCATOR

Group 13
COMMERCIAL GEOGRAPHY
9
Continued from page 5381

NATIONS AS TRADERS

The Natural Regions, Products, and Trade of the Temperate Lands of the Far East, of the Southern Hemisphere, and of North America

By Dr. A. J. HERBERTSON and F. D. HERBERTSON

CHINA proper, with its many millions, has to be distinguished from the belt of its dependencies —Tibet, mainly an icy waste except in the south-east; Chinese Turkestan, a desert fringed with small oases, and valleys with fruit trees, cotton, etc.; Mongolia, a desert of poor steppe land, with camels and horses, and having a slightly more fertile margin; Manchuria, resembling Mongolia, in the west, but fertile and prosperous in the centre and east. Except the richer parts of Manchuria, these are of little economic importance.

The Richer Areas of Southern China. China proper consists of a hilly south and west, and a flatter north. The south has wooded hills, producing lacquer, vegetable wax, leaves for silkworms, tea; while rice, cotton, sugar are cultivated in the irrigated valleys. This region may be divided into five divisions:

(1) The plateaus of Yunnan and Kweichau, rich in gold, silver, copper, coal and iron, with outlets to Red River of Tongking, the Yangtse Kiang, and chiefly to the Si Kiang.

(2) The Si Kiang Valley, with Canton as its capital, and outlet on the delta. Near it is the British island of Hongkong, the great shipping junction of the Far East.

(3) The Eastern Highlands, with a port at the mouth of each valley, Swatau, Amoy, Fuchau (at the mouths of the eastern Min), Ningpo, and Hangchau.

(4) The Lower Yangtse Valley, which is partly in the plains, but its tributaries, the Kan, Siang, and Han, come from hilly lands rich in minerals, especially anthracite and iron, in the Siang basin. This is the valley the railway from Canton to Hankow will follow. Shanghai, on the Wusung, near the mouth of the Yangtse, is the port to which most ocean steamers come, but they can ascend past Nanking to Hankow, at the mouth of the Han, where many routes converge [see also page 2976]. Navigation is possible to Ichang, at the mouth of the gorges, where the river is very rapid, though not enough to prevent small steamers reaching beyond the gorges to Chungking. This is the port of

(5) The Red Basin of Sechwan [see page 2976], the capital of which is Chengtu, on a very fertile, irrigated plain. Coal, iron, salt, and other minerals abound.

The Rich Lands of Northern China and Manchuria. The rich lands of Northern China and Manchuria have a much colder winter than the south, the people are hardier, and even more industrious. The fertile soil, much of it loess, is irrigated and cultivated in the most careful manner, producing millets and pulses. Silk and tea are mainly confined to the south.

We may divide this district into:

(1) The plains south of the Hwang Ho, among the richest lands in China, crossed by the Grand Canal from south to north in the east, and by the railway from Hankow to Peking in the west, and from Kaifeng, where the Hwang Ho leaves the mountains, to Shanghai, near the mouth of the Yangtse.

(2) To the north-east rises the Shangtung peninsula—a hilly land with rich coalfields. Kiauchou (German) is chief outlet. Chifu is the northern port, and Wei-hai-wei a British station in the east of this region.

(3) In the north-west the hilly provinces of Shensi and Kansu, by which the route to the centre and west of Asia passes viâ Singan on the Wei and Langchau on the Hwang Ho. Tobacco is important in Kansu.

(4) The mountains north of the Hwang Ho in Shansi, which are among the richest mineral regions of the world, with anthracite and bituminous coal, iron and copper, which are all now being tapped and will rapidly be exploited as railways are built.

(5) The rich alluvial plains of Northern China fringing the Gulf of Pechili, with Peking to the north, and Tientsin its port.

(6) The plains and hills on East Manchuria, with much more severe winters, shorter, cooler, and drier summers; rich in beans, and capable of growing maize and wheat. The hills are wooded, and contain rich minerals, including gold, as yet little exploited. The railway runs northward from Port Arthur, by Niuchwang (the port), Mukden (the capital), to Harbin, where it joins the Russian Siberian line to Vladivostok.

Industrial Condition of China. We have seen that China is still essentially an agricultural country. It produces food for nearly 400,000,000 people, and imports very little. The needs of such a population are great, for clothing, dwellings, etc. Hence the building of houses, making of cloth, clothes, and agricultural implements are all important occupations. The manufactures, however, are still almost all domestic. An immense internal trade is carried on, but is much hampered by bad means of communication, except on the great waterways, of which the Imperial Canal and the Yangtse are the chief. The numerous customs and other tolls and the monetary system of China also hamper trade. The official coinage is confined to copper cash, of which 35 go to the penny, and most exchanges are effected by silver, which is weighed. One tael weight (a Haikwan tael) is worth one-seventh of a pound sterling = 2s. 10·4d.

Railways in China. The era of railway construction, and the development of mining and of manufacturing by modern mills, which have just begun in China, are destined to effect an economic revolution in a much shorter time than in Europe, and of far greater importance than in Japan. The railway built from Peking to Tientsin, Taku, and Manchuria, from Peking by Paoting to Hankow, which is being extended to Canton; the line round Shangtung from Kiauchou; from Kaifeng to Shanghai; those projected up the Hwang-Wei, Yangtse Kiang, and Si Kiang; the Yunnan railway to Tongking, are among the most important which will bring the greatest cities of the interior in close touch with each other and the outer world, and will tend to develop a great trade.

Present Foreign Trade of China. The trade of China in the year 1904 was as follows:

In Haikwan taels (2s. 10·4d.)			
Imports	Thousands of taels	Exports	Thousands of taels
Cotton goods ..	124,083	Silk, raw and manufactured ..	78,555
Opium	37,094	Tea	30,202
Kerosene oil ..	27,908	Raw cotton ..	24,812
Metals	21,235	Skins (furs) ..	7,328
Sugar	18,281	Beans and bean cake	7,283
Rice	8,380	Hides, cow and buffalo	7,142
Coal and coke ..	7,161	Straw braid ..	4,503

Silk, tea, and cotton, but little produced in Europe, are the chief exports. The tea trade has diminished greatly since India and Ceylon competition came into play, but it shows signs of recovery, as the following table of the amounts sent to the United Kingdom from Hongkong and Macao shows:

Year	lb.	Value £
1890	73,743,000	2,813,000
1895	40,084,000	1,431,000
1900	21,316,000	688,000
1902	17,410,000	492,000
1904	27,240,000	810,000

The following table shows the chief countries with which China trades:

In Haikwan taels (2s. 10·4d.)			
Country	Imports from	Exports to	Total
Hongkong ..	141,085,000	86,858,000	227,943,000
Japan and Formosa ..	50,164,000	37,987,000	88,151,000
United Kingdom ..	57,230,000	15,270,000	72,500,000
Continental Europe (except Russia)	23,513,000	44,513,000	68,026,000
United States	29,181,000	27,088,000	56,269,000
India	32,220,000	2,387,000	34,607,000
Russian Empire	4,468,000	5,056,000	9,524,000

The Hongkong trade is with many countries. Of course, it includes more than the China trade, but an analysis of it will give some indication of how the great values entered in the trade of China under Hongkong are to be distributed.

Thus the interests of the British Empire in Chinese commerce are by far the greatest of those of any other power.

Japanese Empire. The Japanese Empire for trading purposes may be divided into Japan and Formosa. The latter island is noted chiefly for camphor and tea. Gold, silver, and copper are worked.

Japan has been described on page 3159. Its trade may be gathered from the following table for 1904:

In yen (2s. 0½d.)			
Imports	Yen	Exports	Yen
Raw cotton ..	71,467,000	Raw silk ..	88,741,000
Rice	59,792,000	Silk manufactures ..	42,695,000
Sugar	23,043,000	Cotton yarns ..	29,268,000
Mineral oil ..	18,201,000	Coal	14,825,000
Ironwork ..	14,915,000	Copper	12,908,000
Wheat and flour	11,162,000	Tea	12,884,000
Machinery ..	9,883,000	Matches ..	9,764,000
Beans and pulses ..	8,625,000	Cotton manufactures ..	7,075,000

It will be noticed how large a share the industrial life of Japan is playing in its trade. Raw materials, foods, ironwork, and machinery are the chief imports; and while raw silk, tea and minerals are important exports, manufactured silk and cotton and matches are also large items in the goods sent abroad. Japan has progressed farther than China in the development of modern manufacture and commerce. Its resources are nothing like so great as those of China, but we can gain a slight idea of what may happen in China in the near future by studying the existing economic position of Japan.

Countries with which Japan Trades. The comparison of the values of imports and exports for 1904 in the table below shows how Japanese trade relations are developing:

Value in yen (2s. 0½d.)			
Country	Imports from	Exports to	Total
United States..	58,116,000	101,251,000	159,367,000
China	54,810,000	67,986,000	122,796,000
United Kingdom ..	74,993,000	17,644,000	92,637,000
India	68,012,000	9,405,000	77,417,000
France.. ..	3,334,000	36,320,000	39,654,000
Germany ..	28,697,000	4,104,000	32,801,000
Hong Kong ..	2,495,000	28,160,000	30,655,000
Korea	6,401,000	20,390,000	26,791,000
French Indo-China ..	17,400,000	375,000	17,775,000
Italy	674,000	12,071,000	12,745,000
Russian Empire*	6,523,000	81,000	6,604,000

* In 1903 the values for the Russian Empire were: Imports from, 8,559,000; exports to, 3,365,000; total, 11,924,000. Owing to the war, the figures for 1904 are not characteristic.

The United States takes tea and silks, and in return sends manufactured goods, raw cotton, and wheat. The United Kingdom and German trade is largely one of manufactured goods sent to Japan, from which is taken a very much smaller value of produce. The trade of France and Italy presents a very great contrast, for it is one in which raw silk from Japan to Europe plays a great part, while the exports from these countries to Japan are very small. On the other hand, India sends Japan most of its raw cotton and also much rice from Burma.

The Japanese trade is thus the most complex we have yet studied.

The Three Types of Land already Studied. We have now examined three different types of countries from the commercial point of view: (1) The poor lands of the icy and arid deserts and their margins, of little commercial value save for mineral and animal products; (2) the rich vegetations of the hot, wet forests and bordering savanas, largely self-sufficing, only here and there exploited for trade purposes, mainly where plantations have been formed under European supervision; (3) the rich lands with regular seasons—dry winters and wet summers, with large alluvial lands easily flooded and cultivated, with a long civilised history, with well-developed internal trade, hindered only by lack of easy communication, which is gradually being overcome. In India European direction has introduced modern means of transport, but the exploitation of the country is in native hands, and while European capital has been sunk in factories, these are not all so financed, and are worked mainly by native labour.

In Japan the European factor has been less important, and the stage of industrial evolution is beyond that of India. It is likely to be pushed further

almost entirely by the Japanese themselves. China is on the point of adopting all the more modern methods of production and communication, and it possesses probably the richest resources and the most numerous and laborious population in the world. There we may expect to find in the future the most striking economic developments not directed by European energy.

The Three Types still to be Studied. We have now to turn to those lands, almost entirely in the temperate regions, in which Europeans live and control the economic life. Three types may be studied: (1) the countries where the rural occupations are everything and industrial pursuits yield a very small part of the wealth of the country—*e.g.*, the European settlements in the southern hemisphere, in Western Canada and United States, and Asiatic Russia are of this type; (2) countries such as Eastern Canada, Central and Eastern United States, and most of Europe, except the west and centre, where industrial development is of great and growing importance, but in which the rural populations are still of great significance in their trade; and (3) such countries as Germany, Switzerland, France, Holland, Belgium, and, above all, the United Kingdom, in which the industrial development has proceeded still farther, and forms the chief source of their commercial activity.

The Main Economic Divisions of Southern Temperate Lands. We may divide the south temperate lands according to temperature and rainfall into: (1) the Eastern wet regions, with hot summers and warm winters; (2) the central and northern hot arid areas; (3) the eastern regions, with warm summers and cool winters and fair rainfall, mainly in summer; (4) the western regions, with warm summers and with cool winters, during which most of the rain falls (Mediterranean type of climate); (5) and (6) the small regions of cool summers and cold winters, with rain at all seasons, little in the east, heavy in the west.

The Warm, Wet, Eastern Regions of Summer Rains in the South. Immediately south of the tropic of Capricorn lie in the east regions with warm winters and hot, wet summers where growth is checked only by drought. A considerable part of this region is well wooded, yielding fair timber. In clearings and grassy patches can be grown in the warmer parts some of the produce of intertropical lands, such as sugar, coffee, cotton, and rice, but the chief cereals are maize in the moister and warmer, and wheat in the drier and cooler parts. Tea, pineapples, arrowroot, tobacco, oranges, lemons, and many other fruits are among the other products of this type of region, which is to be found in Southern Brazil, Uruguay, Paraguay, and Eastern Argentina north of the Plate in South America; in Natal, the Eastern Transvaal and Cape Colony in South Africa; and in Eastern Southern Queensland and New South Wales in Australia. These roughly correspond to China and Southern Japan in their climatic conditions and economic vegetation; but the human conditions are very different, for the population is nowhere very dense, and cultivation is largely for a foreign market.

Grassland Zone between the Wet Zone and the Desert. Between the wet, forested east and the arid and desert, or almost desert, centre and west stretches a grassy area, capable of cultivation in the east and round irrigated areas in the west. While in the east the plants already named appear, in the drier irrigated areas plants of Mediterranean type, such as vines, figs, peaches, flourish. The chief wealth of these regions, however, is the livestock, cattle in the moister and sheep and goats in the drier parts, tended by men on horseback. The mineral wealth varies greatly in different areas, and can be studied most conveniently under each country.

Hot Arid Regions. The central and western hot arid regions consist of the margin of the southern deserts, and are of little value save when irrigated. The irrigated areas are (1) in the west of Argentina, near the base of the Andes; (2) small areas in Bechuanaland and the Karroos of South Africa; and (3) in extra-tropical Southern Australia and the adjoining portions of Queensland, New South Wales, and Victoria. Here, Mediterranean fruits, maize, and lucerne (alfafa) are the chief products. The Mildura Colony of Victoria uses water pumped from the river Murray.

Outside the irrigated region the lands produce a poor scrub, which feeds small numbers of sheep, goats, and ostriches. The value of the land can roughly be judged by the rainfall. This is well shown by the following table, taken from a paper by Mr. Willis, in the "Scottish Geographical Magazine," for 1887:

District.	Number of sheep per sq. mile	Mean rainfall in inches
South Australia, dry area ..	8 to 9	8 to 10
New South Wales, dry area..	96	13
New South Wales	640	20
Buenos Aires	2,630	34
Irrigated land in California growing lucerne equal to about..	12,000	60 to 100

This record shows how a series of dry years must reduce stock by lowering the power of the land to support large numbers.

The Mediterranean Type of Land. The Mediterranean type of land in the southern hemisphere has warm, dry summers, similar to those of the regions just described. It differs from them in enjoying a fair, or even heavy, rainfall in late autumn, winter, or early spring. This means that the moisture comes in the coolest part of the year, when other conditions of growth are not so favourable. The hot summers allow of the cultivation of cereals and of such Mediterranean fruits as the grape, fig, orange, pomegranate, and olive; and here, as in Europe, the Mediterranean realm is one of corn and wine and oil. When irrigation is possible, and the supply of water in summer is sufficient, this type of region is very fruitful, as is shown by the Californian figures of the last paragraph.

This type of region is found in (1) Central Chile; (2) South-west Cape Colony; and (3) south-west of Western Australia, south of South Australia, Victoria, and the North Island of New Zealand. In the south of Australia the products are mainly wheats and fruits, with a little timber.

Sir Charles Todd has made a valuable study of the relation of rainfall to crops. Taking the mean rainfall for the winter six months, and comparing the amount with the yield of wheat in bushels per acre over a series of years, he finds the following relation. The seven best years, with an average yield of 12·43 bushels per acre, had 18·47 in. of rainfall. The five next best years, with an average yield of 10·02 bushels per acre, had a rainfall of 15·28 in. Six bad years, with an average yield of only 6·61 bushels per acre, had so small a rainfall

as 13·55 in. From this we may also infer that there is a steady proportional increase in the yield of wheat per acre from the drier to the wetter parts of these lands.

One compensation possessed by the drier areas is that the quality of the produce is usually excellent, and the hard wheats of these dry areas command higher prices. [See AGRICULTURE.] Many of the trees round the margin of the dry areas yield excellent hardwood, in particular the jarrah and karri of South-western Australia. [See MATERIALS AND STRUCTURES.]

The Trade of the Mediterranean Type of Lands. Most of these regions do little more than support themselves, and some do not manage to do even that, as a study of statistical tables shows. The exports are mainly minerals, wool, hides, and ostrich feathers from South Africa; timber from West Australia; wines from South Australia; and dairy produce and wines from Victoria. In examining the statistical tables, it must not be forgotten that in the case of all, except Victoria, the produce of other regions is included in the returns, as political and natural geographical boundaries by no means coincide. The trade of Chile, for instance, is mainly in nitrates from the northern deserts, and in copper, silver, and iron. These are independent of climate, and if we exclude them, wool is the only other export of much value.

Textiles and wearing apparel, machinery, railway plant, hardware, and articles of luxury, are the chief imports to these lands. The smallness of the market, and the cost and scarcity of skilled labour are the chief hindrances to the development of local manufactures on a large scale.

Typical Trade Returns for Warm Temperate Lands. Let us next examine the trade of Uruguay and Natal as types of the eastern lands of the warm temperate zones. In this case, in order to obtain values which may be compared we shall not quote the actual values of the statistical tables, but calculate the percentage which the value of each group of products bears to the total value. This is a valuable method of comparing statistics which the student should accustom himself to use. The values can be calculated from the total trade which is given at the top of each column.

In Uruguay, the country is only beginning to be occupied, and, as yet, little is broken by the plough, so that cattle rearing is the chief occupation. In Natal, cattle and sheep are reared on the higher slopes, but the lower warm lands near the coast are partly cleared and cultivated, mainly by Indian coolie labour. In New South Wales very similar climatic conditions prevail. The drier interior is pastoral, the wetter east of the higher plateau cultivated wth wheat, but the lower slopes round the coast grow maize, etc. Here, the European alone works, and a more energetic, prosperous, and homogeneous community is growing up. In New South Wales the wealth of coal and gold is much greater than in the other lands, and is extracted by modern methods. Manufactures are rapidly developing.

Uruguay. Total exports, £8,240,000	per cent.	Natal, 1903 to 1904. Total exports, £1,356,000	per cent.
Live animals	2·6	Animal products ..	26·0
Animal products ..	90·0	Sugar	6·1
Agricultural products	5·1	Coal	29·6
Other	2·3	Other*	38·3

* Excluding gold.

The Cooler Southern Lands. The cooler southern lands, with fairly constant rains, comprise (1) South Chile, (2) Tasmania, and (3) the South Island of New Zealand, which lie in the track of the westerly storm winds. The rain suffices for dense forests on the western slopes of the mountains, which are as yet little exploited for their timber. In some of the upper grassy valleys cattle are kept, especially in New Zealand. The mineral wealth is a very valuable asset, especially coal and gold in New Zealand. The potentially rich fisheries are not much developed.

The eastern side of these lands is much drier, and a chinook or föhn wind effect is frequently recorded. In Patagonia the country is as yet little developed, save for a few sheep runs and gold-mines. The Canterbury plains of New Zealand are rich in grazing ground, where many sheep are fed. The mutton is sent in refrigerating chambers to Britain, to which the wool and hides are also exported. Part of the land is cultivated with wheat. In the extreme south and in the higher lands oats are grown.

The Trade of New Zealand. The trade of these lands is small, except in the case of New Zealand, the statistics for which, however, include the produce of the warmer Northern Island. The export of meat and dairy produce is of recent growth, owing to the modern methods of refrigeration. Quite recently, experiments in preserving meat by oxygenisation are said to have proved successful, and an early application of the process is probable. The cost is said to be much less, and the increased demand, following from the reduction in price, would doubtless stimulate the trade.

Exports from New Zealand, 1904.		Imports to New Zealand, 1904.	
Wool	£4,674,000	Clothing and textiles	£3,006,000
Frozen meat ..	2,794,000	Iron, steel goods, and machinery	2,558,000
Gold	1,988,000	Paper, books, and stationery ..	581,000
Butter and cheese	1,566,000	Sugar	505,000
New Zealand flax	710,000	Alcoholic drinks	357,000
Hides, skins, and leather	564,000	Oils	278,000
Kauri gum	502,000	Tobacco and cigars	255,000
Other articles ..	1,950,000	Tea	238,000
		Other articles	5,514,000
Total	£14,748,000	Total	£13,292,000

This is a very remarkable trade for three-quarters of a million people. It gives a very fair idea of the economic conditions in that part of the southern hemisphere which most resembles our own island home.

Economic Divisions of Temperate North America. The present economic development of the North American lands is at very different stages. North America has been much longer settled by Europeans than has Australia, and its resources have been much more systematically and energetically exploited than those of Argentina.

The *Physical Divisions* roughly correspond with the economic ones. Broadly, they consist of (1) the mountainous west; (2) the central plains; and (3) the highlands and coastal lowlands of the east. [See North America, page 4172.] Climatic conditions control the subdivisions of the vast central plains into tundra, forest, wheat, maize and cotton belts, and the drier uncultivated grasslands of the higher western plains. Mineral wealth and

density of population are other factors which must be taken into account in the various subdivisions, each of which has its own natural products and its characteristic economic conditions.

The Western Mountains. The high plateaus and intermont plains on the east of the western mountains are of little economic importance, except for stock raising. The centres of settlement are (1) round such irrigated areas as those of Utah, especially round Salt Lake City; (2) in the plains at the mountain base, where the waters of the snow-fed rivers are carried over the plains; and (3) in the mining centres, which are especially numerous in Colorado, Montana, California, Southern British Columbia, and Klondike. Gold, silver, copper, and lead are the most abundant minerals.

The western valleys of the western mountains are much more favoured climatically. The temperature is equable and the rainfall is abundant and well distributed throughout the year north of California, while in that state the winter rains are sufficient except in the extreme south, which gradually becomes more desert-like.

South-western British Columbia, Washington, and Oregon are penetrated by straits and inlets, which permit easy sea communication. The most important of these openings are Puget Sound, with the ports of Olympia, Tacoma, and Seattle, and the straits round Vancouver Island, with Victoria on Vancouver Island, Vancouver on Burrard Inlet, and New Westminster. The last two are outports of the Fraser basin. Farther south are Portland and Astoria, on the Columbia River, the outlet of the wheat lands of the Willamette Valley.

The lumber yielded by the forests of giant Douglas pines, the salmon of the numerous rivers, and the mineral wealth—gold, silver, lead, and copper—of the interior, find an outlet through these ports. Grain from the western plains is now being brought to them in increasing quantities by the Canadian Pacific, the Great Northern, and the Northern Pacific railways for shipment across the Pacific. Coal is a very important export, as it is uncommon on the eastern coast of the Pacific between Puget Sound and Central Chile. Local iron ore is being smelted round Puget Sound, and shipbuilding and engineering works are being constructed. The development of this region is likely to be great and rapid.

The Wealth of California. California has a much larger area of plain than the lands farther north. Its climate is of the Mediterranean type, with winter rains. Orange, lemon, and olive groves, vineyards, peach, apricot, apple, pear, and other orchards, fields of maize, wheat, and lucerne, many of them irrigated, form its chief sources of wealth. In 1850 there were not 100,000 inhabitants in this state, which is three times the area of England. To-day there are 1,750,000. The discovery of gold in 1848 attracted adventurers from all parts of America and Europe. Since then nearly £300,000,000 of gold has been extracted, and in 1904 about £3,800,000 was obtained. Nevertheless, it is the agricultural rather than the mineral wealth which has led to the remarkable development of California. The absence of coal has retarded the industrial development, but electricity is now generated by water power, and petroleum is much used as fuel for industrial purposes.

California possesses one of the finest harbours in the world, at the entrance to which, known as the Golden Gate, is built San Francisco, with its 360,000 inhabitants. This is the chief port in the eastern Pacific, with steam lines for all parts of the world.

The Central Plains North of the Missouri and Ohio. Furs and lumber are the economic products of the tundra and forests. The latter industry is very important round the Great Lakes, the St. Lawrence and its tributaries, where lumber is sawn and made into joiner's work and wood-pulp for exportation. The grasslands and the forest clearings are cultivated with wheat, and towards the south with maize. In the drier west, stock is raised on the natural "buffalo" grass. In the agricultural area hogs and cattle are fattened on maize and the offal from the flour mills. Round the Great Lakes are rich supplies of iron and copper ore, and farther south are vast coalfields which supply power for many growing industrial centres. The St. Lawrence and the Great Lakes and the Mohawk-Hudson valley are the chief natural routes from the east to this area, which has other outlets across the Appalachians and down the Mississippi. Three aspects of the economic life of this area deserve more detailed study: (1) The Canadian conditions, (2) the agricultural belt of the United States, and the industrial development consequent on its needs, and (3) the metallurgic activities of the eastern portion and the mining on which it depends.

Canadian Commerce—Exports. Let us once more turn to statistical tables, which will give us a clear conception of the most important aspects of Canadian commerce, derived, as it is, mainly from this region. The value of the exports from Canada in thousands of dollars ($1,000=£206) for the three years 1903, 1904, 1905, is as follows:

Exports from Canada	1903	1904	1905
Mining products..	31,062	33,619	31,932
Fishery products	11,800	10,759	11,114
Forest products..	5,300	4,930	3,267
Animals and their products	69,818	63,812	63,338
Agricultural products ..	44,624	37,139	29,994
Manufactures	51,714	48,034	51,160
Miscellaneous	84	122	50

The 1905 figures may be further analysed as follows: Gold quartz accounted for $15,210,000, copper ore for $4,860,000, coal for $3,930,000, and silver ore for $2,100,000. Of fresh and salt water animals and fish, lobsters were the most important, accounting for $3,130,000, codfish was valued at nearly $3,000,000, and salmon at $2,160,000. Of forest produce manufactured, wood was worth $32,216,000 and wood-pulp $3,400,000. Cattle were the most important animals, valued at $11,360,000. Hides accounted for $2,710,000, leather for $2,340,000, and furs for $2,400,000. In the dairy industries bacon was worth $12,200,000, butter nearly $6,000,000, and cheese (the most valuable of all) brought in over $20,000,000. Of the produce of the fields, wheat is the most important, accounting for $12,400,000, and for nearly $6,000,000 more in the form of flour, while fruits amount to over $3,270,000. The minerals are from the western mountains and the maritime provinces. Salmon is obtained mostly from the western, the other fish from the eastern waters. Of the other products from the regions more particularly under consideration, wheat is obtained from the central plains, with Winnipeg as its collecting and distributing centre. Dairy produce and cheese are almost exclusively from Ontario and Quebec, and fruits from the Niagara peninsula and Nova Scotia.

All these exports are carried mainly across the Atlantic. The St. Lawrence forms the chief outlet for this trade in summer. In winter, when it is frozen, Halifax, St. John, N.B., and the United States

ports have to be used. In 1904 Montreal shipped nearly $60,000,000 worth; Quebec, $3,700,000 St. John, N.B., $13,600,000; and Halifax, $8,500,000; while Vancouver on the Pacific only handled $5,300,000 worth. In the same year 35 per cent. of the exports were to the United States, and 55 per cent. to the United Kingdom. The West Indies, the next market on the list, took only 2 per cent.

Imports to Canada. The following table shows the nature of the imports and how far they pay duty. The value is again given in thousands of dollars ($1,000 = £206):

Nature of Imports to Canada, 1904	Dutiable	Free	Duties collected	Averate rate of duty on dutiable goods
Food and animals	20,900	12,596	5,000	23·9
Raw materials for domestic industry	10,324	39,668	2,300	22·3
Wholly or partially manufactured materials for manufacture and mechanical arts	23,942	22,913	5,216	21·8
Manufactured articles ready for consumption	77,262	18,693	19,237	24·9
Luxuries, etc.	16,482	810	9,201	55·8
Total	148,910	94,680	40,954	29·7

Of the manufactured articles, iron and steel are by far the most important, amounting in 1905 to almost $42,000,000. A very large proportion comes from the United States, as do the imports of coal and coke, which are valued at $21,250,000. Woollen manufactures, which are next on the list ($15,600,000), enter from Great Britain under the preferential tariff, as do cotton goods, worth $8,600,000. Cotton-wool and waste ($6,000,000), free of duty, and tobacco ($3,000,000), also mainly duty free, enter for the manufacturing centres of Montreal, Western Quebec, and the Lake peninsula. Sugar ($9,250,000) and fruits (over $5,000,000) come largely from the West Indies. The United States does more than any other country to supply Canada's needs, to the extent of 60 per cent. The United Kingdom supplies less than 24 per cent., and Germany, France, and the West Indies come next in order.

The ports by which these imports enter are of interest. Montreal still heads the list with $78,500,000; but Toronto comes next with over $50,000,000. Halifax and Quebec have over $8,000,000 each, St. John, N.B., $5,600,000, and Vancouver, $6,150,000.

The Central United States. As in Canada, the west of the United States is a ranching country, raising cattle and sheep. East of 100° W., the rainfall is sufficient for agriculture. Wheat is the staple crop in the north, and maize in the south. Most wheat is grown in the Red River valley and the Dakotas, but it is cultivated even south of the Ohio mouth. Much of the crop is forwarded to the Lake ports (Duluth, Superior, Chicago, etc.) and sent by the Great Lakes to Buffalo, where most of it is put on the rail for New York. Part of it goes by rail the whole way to the eastern and Gulf ports. An increasing amount is sent by rail across the Rocky Mountains to Puget Sound. The cost of transport has been extraordinarily diminished in America. To lessen its ratio to the value of the freight a large proportion of wheat is milled into the more valuable and compact form of flour. Minneapolis, where the Falls of St. Anthony supply water power, Superior, Duluth, Kansas City, and many cities farther east, are important milling centres.

Similar considerations of economy lead in the maize belt to the fattening of cattle and hogs on the crop raised. The stock and the cattle and sheep from the ranches are slaughtered and sent east as "chilled meat" in refrigerated trucks. Enormous quantities are "packed" or canned. The hides are made into leather. The wool and hair, bones, sinews, and even the blood and offal are utilised in various ways. The mutton is sent mainly to the Eastern States, but much beef is exported. The chief meat packing cities are Omaha and Kansas City on the Missouri, and Chicago. Formerly Cincinnati was the "Porkopolis" of the United States, and St. Louis rivalled Chicago. As settlers moved westwards new meat cities grew up, but the old ones still retain a fair trade.

These regions need railway plant of all kinds, agricultural implements, and the clothing, luxuries, and other requirements of a population which is not, like many of the Old World peoples, self-supporting. The railway has been in many cases the precursor of settlement, for without it the settler could neither procure supplies nor send his produce to market.

The Industrial Region East of the Mississippi. A generation or so ago the now busy and populous region east of the Mississippi preserved the same characteristics as the region just described. Now all is changed. Coal is widely distributed and mined, and used at all the great and growing cities for their numerous and varied manufactures. Between Western Pennsylvania and Illinois are many oil and natural gas wells, which supply a valuable fuel. The petroleum is conveyed in pipes to Chicago, Pittsburg, Cleveland, Buffalo, New York, Philadelphia, Baltimore, and other cities. Iron ore and limestone occur in the Western Pennsylvania coal, oil, and gas field, with the result that this region has become one of the leading steel-making centres of the world. The local ore no longer suffices. Fortunately, iron ore is abundant round Lake Superior, whence it is shipped in giant "whale-back" steamers to Chicago and the ports on the southern shores of Lake Erie to be smelted. Much is carried by rail to Pittsburg, the greatest iron and steel city in the world. Here, again, remarkably low rates of carriage have led to an extraordinary economic expansion. The ore is carried to the fuel because the fuel is near the markets for the finished products.

The Central and Southern Atlantic Plains. The Central Plain south of the Ohio and the Southern Atlantic Plain is a hot region where cotton is the most important crop. Tobacco is grown in the north and sugar in the south. Throughout this region the labour problem, which is a difficulty in many hot lands, was formerly overcome by the importation of slaves, mainly from Africa. Since their emancipation these negroes have still remained the chief cultivators of the ground. Nearly three-quarters of the raw cotton of the world is grown in this area. Most of it is shipped to Europe (half to England) and New England from Galveston, New Orleans, Mobile, Pensacola, Savannah, Charleston, Wilmington, and even Baltimore. The sugar and rice of the south are not much exported. The tobacco of the northern margin of this belt is exported, the great

markets being Richmond (Virginia) east, and Louisville (Kentucky) west of the Appalachians.

The Southern Appalachian coal and iron field has only recently been adequately exploited. Steel and iron are made round Birmingham (Alabama). A remarkable feature is the rapid development of the cotton manufacture of Atlanta and other manufacturing centres of the other States, but unhappily child labour is largely used to cheapen production and supply the necessary amount of labour.

The New England Manufacturing Area. One of the earliest English settlements in North America was on what is now known as the New England coast. Gradually the pioneers made their way inland across a rather poor highland into the parallel fertile valleys. These diminished in agricultural importance with the opening up of the prairies in the west. The irregular shores of New England afford good harbours, but fishing and the building of ships with timber from the forested hills have both declined. The result is that New England has specialised in manufactures, a development rendered easier by the abundance of water power. With improved facilities of transport coal is brought from Pennsylvania by sea and rail, while cotton is imported from the south and wool from the east over sea. Leather, boots, clothing, ironmongery, clocks, watches, and many other articles are manufactured. Economically there is a marked tendency for the more skilled occupations to expand while those employing less trained labour pass elsewhere. The manufacture of coarser cottons has thus been transferred to the South Appalachians. The chief New England cotton centres are Lawrence, Lowell, and Manchester on the Merrimac River, Augusta and Waterville on the Kennebec, and other cities on the New England rivers, not far from the coast. Fall River, in Rhode Island, is also a seaport, and the consequent reduction in transport charges has made it the largest of all. Woollen factories are more widely distributed. Lawrence and Lowell are busy centres. Carpet-making is important at Lowell and Hartford. Lynn, Brockton, Haverhill, and other towns make boots and shoes and Waterbury watches. Worcester is a great engineering centre. There are many towns with varied manufactures, especially of ready-made clothing. Of these industrial centres Boston is the chief port, but it is cut off from the great western industrial and agricultural area by the Berkshire and other Highlands of Western New England.

The Central Eastern Industrial Area. The central eastern industrial and commercial area is very important. The great inlets which penetrate to the "fall line" make admirable waterways to the manufacturing centres, which are grouped round the anthracite fields of Eastern Pennsylvania. Many large towns are noted for special industries, but in this area engineering, especially in Philadelphia and New York, is even more important than textile manufactures. Philadelphia is the chief locomotive and shipbuilding centre in America. Locomotives are also constructed at Paterson, near New York, Scranton, Richmond, and other centres. Ready-made clothing is an important industry in New York, Philadelphia, Baltimore, and other cities in the States.

The central eastern ports are Baltimore, Philadelphia, and New York, which have already been described on page 4172.

Exports and Imports of the United States. The exports of the United States are gradually altering in relative importance. In the early nineties 80 per cent. of the exports consisted of agricultural produce, but in 1904–5 these were only 55 per cent. The figures are, in round numbers:

Cotton unmanufactured	$380,000,000
Provisions, including meat and dairy produce	170,000,000
Iron and steel, and manufactures thereof ..	135,000,000
Bread stuffs	108,000,000
Copper, and manufactures thereof	87,500,000
Mineral oils	80,000,000
Wood, and manufactures thereof	58,000,000
Cotton manufactures	50,000,000
Animals	47,000,000
Leather, and manufactures thereof	38,000,000
Tobacco	35,000,000

The chief imports for 1904–5 are, in round numbers:

Sugar	$97,500,000
Coffee	84,500,000
Chemicals, drugs	65,000,000
Hides and skins	65,000,000
Raw silk	61,000,000
India-rubber	51,500,000
Cotton manufactures	49,000,000
Raw wool and hair	46,000,000
Fibres, vegetable and textile grasses, manufactures of	40,000,000
Fibres, vegetable and textile grasses, raw ..	38,000,000
Diamonds and other precious stones	34,000,000
Wood, and manufactures of	29,500,000
Iron and steel, and manufactures of	23,500,000

The iron and steel exports are thus nearly six times the value of steel imports; whereas in 1885 they were only half, in 1895 one and a half times the value of the imports.

Countries with which the United States Trades. The United Kingdom is by far the best customer of the United States, and sends it most of its imports. Germany comes second in both capacities. The totals for the chief countries for 1904–5 are given in 1,000 of dollars in the subjoined table which students can examine in greater detail.

Country	Exports to	Imports from	Total Trade
United Kingdom ..	523,397	175,812	699,209
Germany	194,220	118,268	312,488
Canada	142,979	63,654	206,633
France	76,337	89,830	166,167
Brazil	10,985	99,843	110,828
Japan	51,719	51,822	103,541
Netherlands	73,298	21,719	95,017
China	53,453	27,885	81,338

The United States is a vast country nearly as large as the whole of Europe, with a greater variety of climate and products, and with even greater mineral wealth. Consequently we must compare the vast area for internal trade which exists in the United States with that of Europe. The same fact should be borne in mind when we compare the foreign trade of the United States with that of our own country or of any other single country in Europe. Within a very short time the United States' foreign trade ought to far surpass that of any other country. This, however, need give us no cause for patriotic misgivings. The world's wealth of purchasing is not a fixed and exhaustible quantity, but one that is ever increasing, and we may view the success of other countries without alarm so long as our own trade shows no sign of shrinkage.

Continued

1. Sawmill at the Midland Railway Works, Derby

2. Interior of Sawmill (Marshall, Sons & Co., Ltd., Gainsborough)

MODERN SAWMILL PRACTICE

THE MODERN SAWMILL

Importance of Machinery in Woodworking. Woodworking Economy. Sawmill Arrangements

By FRED HORNER

PRACTICALLY all the industries of the world are indebted more or less to woodworking machinery. The hand methods of the carpenter or joiner are not applicable in manufacturing in quantity, and machinery, therefore, supplants the human element, with resulting advantages from the points of view both of output and of accuracy. The classes of operations include those of cutting, scraping, and abrading, by which the cutting up and finishing of wood are effected. Both plane and curved faces are treated. The division of timber is carried out with saws in the first place, termed *breaking down* or *breaking up*, followed by *re-sawing*, which cuts it into smaller pieces of various shapes. These are further treated on machines which plane, mould, mortise, tenon, carve, dovetail, turn, bore, smooth, and polish as required, some of the operations being obviously unnecessary on certain work, while on other classes every one may be carried out. An important point concerning most woodworking machinery is that of repetition work, by which economical production is secured, by setting the machines to deal with definite sizes, and then running them for all they are worth, turning out hundreds or thousands of duplicate pieces, if possible. At the same time, jobbing work must be catered for; but the machines for this kind are, as a rule, simpler and plainer in construction than those for repetition work, being deficient in some of the guides, special cutters, and other details employed.

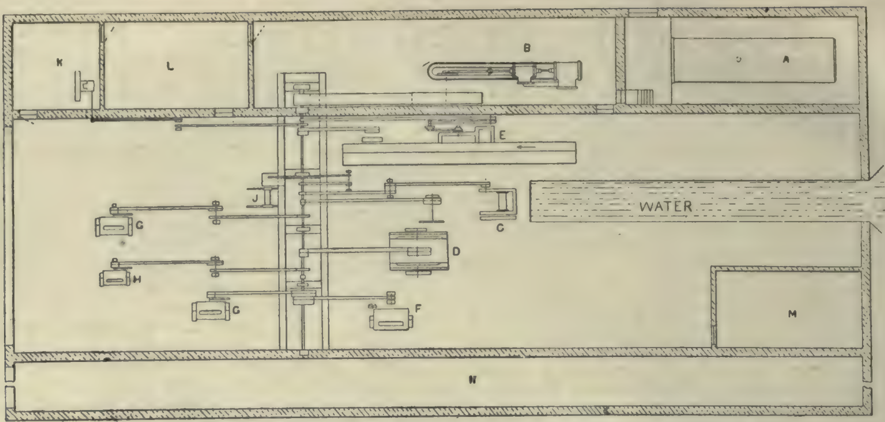
The Sawmill. The producers of "wood goods," as they are termed, have a very varied scope. There are the sawmills, which limit their range to the production of sawn balks, deals, flitches, battens, planks, and boards, etc., which they supply to firms who work them up into finished articles; others go further, and plane, mould, and otherwise convert the stuff into semi-finished or finished goods, such, for example, as various joinery, doors, sashes, mouldings, etc. Then there are the self-contained factories, which include their own sawmill, and engage in the production of completed articles—frequently specialities, as furniture, carts and carriages, railway work, boxes, etc. One difference between the last-named class and the sawmills proper often lies in their respective situations. The sawmills prefer to lie near the source of timber, or at least within range of its convenient transit by water or rail, which explains why there are so many sawmills in Canada, Scandinavia, and the other timber countries.

The British Isles receive a great quantity of timber from Canada, Sweden and Norway, both in semi-finished and in finished forms, especially in the form of building requisites. The lumber industry, with which we are not directly concerned here, gives employment to a large section of men whose work it is to fell the trees, trim them, more or less, and convey them to the sawmills. The most economical method of conveyance is by water, but a certain amount of land transit is necessary before the logs can be sent into the water, the timbers being dragged bodily along, or carried on carriages.

Position of Sawmill. The choice of position for the sawmill depends on a good many circumstances. It is not sufficient to be within convenient touch of the timber-producing areas, but the method of passing the converted wood to the consumer has to be taken into consideration. There are four modes of conveyance to distances—river, sea, road, and rail, the two first-named being the cheapest. On the contrary, in inland districts, where there is no water available, or the products of the sawmill are simply converted into finished goods on the spot, the choice of position is not so important, but must depend on the railways, or in certain cases on roads. The question of getting coal for producing the power to drive the mill does not often enter into calculations, as it would in many industries, because the waste chips and sawdust are utilised in the boiler furnaces, being conveyed thereto by pneumatic conductors. Where a supply of electricity can be obtained cheaply the steam plant may be dispensed with altogether. Other sources of power are gas, oil, and water. These subjects will be considered at the end of this course.

Lay-out of Mill. A sawmill should be designed in such a way that the logs are brought in at one end and pass right through to the other, and so out in their converted state, instead of being handled about to and fro, and perhaps even carried out at the same place as they entered, with consequent interruption and hindrance to the sequence of operations. There are two classes of mills in which different conditions prevail: those that have their logs brought by water, and those that depend on railway transit. In the first case there is no need to provide ground area for stacking the logs, because they are simply left in the water and dragged out as required; in the second, a good space must be provided, upon which a stock of logs is piled, to keep the mill well supplied. This involves a gantry and overhead travelling crane, or a portable steam-crane to pick the logs up and place them on the stacks. The overhead traveller is the more useful type to adopt, because it completely covers the area, and does not get in the way of the piles of timber. The crane must also run over the machines, in order that it may place the logs upon them. The capacity usually ranges up to 10 tons, a 5-ton crane sufficing for the average mill. *Clips* resembling those used for handling stone are employed to grip and lift the logs, the two pincer points penetrating into the wood as the chain is pulled up. When it happens that the logs have to be taken to the mill by road, a four-wheeled *timber carriage* is used, or a *timber jim*, with two wheels and a bent axle, beneath which the log is slung.

When logs are floated right up to the mill, they are drawn out of the water by a hauling chain, operated with a wheel or barrel and gearing. The chain either has a hook on its end to hitch on the logs, or it is endless, and provided with several hooks, or dogs, which are brought into contact with the logs to pull them along up a slope leading from the water to the interior of the mill.



3. PLAN OF SAWMILL HAVING SUPPLIES BROUGHT BY WATER

A. Boiler B. 25-h.p. tandem compound engine C. Log-hauling apparatus D. 60-in. breaking-down frame E. 72-in. rack bench with 40 ft. of table F. 6 ft. by 3 ft. 6 in. roller-feed saw bench G, G. 5 ft. by 3 ft. roller-feed saw benches H. 4 ft. by 2 ft. roller-feed saw bench J. Cross-cut saw bench K. Frame-saw sharpening-room L. Stores and engineer's shop M. Manager's office N. Shed for cut timber

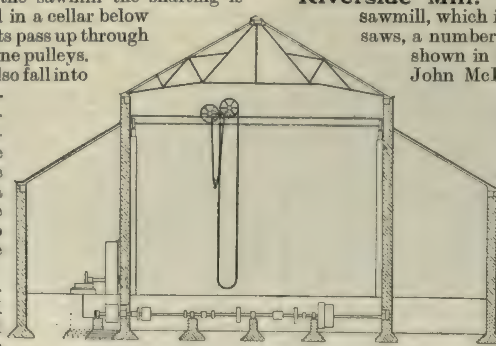
Typical Sawmills. There are five classes of machines used for converting logs into deals, flitches, planks, boards, etc. They are the *frame* saws, the *horizontal reciprocating* saws, the *horizontal band* saws, the *vertical band* saws, and the *circular* saws. Before dealing with the various points of these it will be well to illustrate some typical sawmills, in order to give an idea of the lay-out of the plant. The references to machines will be understood by comparison with details given later.

Figure **5** gives a side elevation and plan of a mill laid out by Messrs. A. Ransome & Co., Ltd., Newark-on-Trent, for a firm in Holland. The power is supplied by a 27 ft. by 6 ft. Cornish boiler, A, supplying steam to a 25-h.p. engine, B, running at 100 revolutions per minute. The flywheel is belted to a pulley on a line of shafting lying below the floor level, a method of driving which is usually followed in sawmills because it leaves the mill entirely clear for the handling and passage of timber, and does away with the trouble consequent upon suspending heavy shafts and pulleys from the roof, where, moreover, they would be in the way of the cranes. In this respect the practice is exactly opposite to that of machine shops, which have overhead counter-shafts, fixed in the roof or on walls, to drive down to the machines. In the sawmill the shafting is carried in bearings fixed in a cellar below ground level, and the belts pass up through the flooring to the machine pulleys. The chips and sawdust also fall into the underground chamber, whence they are conveyed to the boiler furnace, thus leaving the floor always clear. The arrangement also gives a good foundation to the bearings, and tends to reduce vibration at the high speeds necessary.

In the mill under consideration the engine and boiler-house is separated from the mill proper, the latter being a building 92 ft. long by 30 ft. wide. The logs are first passed on to the table of the 48 in. log frame, C, taking logs up to 50 ft. in length, the carriage running upon rollers laid on the floor of the mill from end to end, as seen in both views. A 24-in. by 6-in. deal frame, D, is located alongside to cut the deals into boards.

Mill for Water-borne Logs. A type of mill which has its raw material brought by water is illustrated in **3** and **4**, the first being a plan and the second a cross-sectional view. The list of references beneath the former indicate the position of the various machines. As seen in the section, the line of shafting is carried in bearings mounted on brickwork piers in the tunnel extending across the mill from just inside the engine-room. The mill is 144 ft. long by 40 ft. wide. It will be noticed that the logs are floated right inside by having a water inlet (marked "Water") leading from the river, the hauling apparatus at the end of the channel dragging the logs out, after which they are lifted by the overhead hand traveller [see **4**] and placed upon the carriage of the log frame, and treated afterwards on machines of other classes for further cutting up. This example is that of a plant supplied to a firm in Bankoff, by Messrs. W. B. Haigh & Co., Ltd., Oldham.

Riverside Mill. A very complete class of sawmill, which includes, besides the frame-saws, a number of circular-saw benches, is shown in **6**, from a design by Messrs. John McDowall & Sons, Johnstone. The references beneath are fully explanatory. The logs are brought in this instance by river, and are hauled up two slip-ways, a method which is very commonly adopted. Trolley-ways passing inside the mill communicate with outside lines of rails, enabling the sawn products to be taken out expeditiously. The large number of machines require the installation of



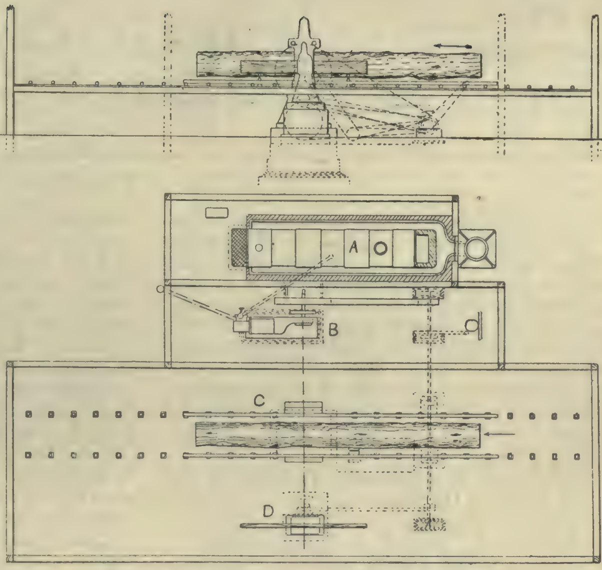
4. SECTIONAL ELEVATION OF 3

two lines of shafting below the floor, driven by ropes from the engine, which is supplied with steam by two Lancashire boilers, with sawdust-burning furnaces.

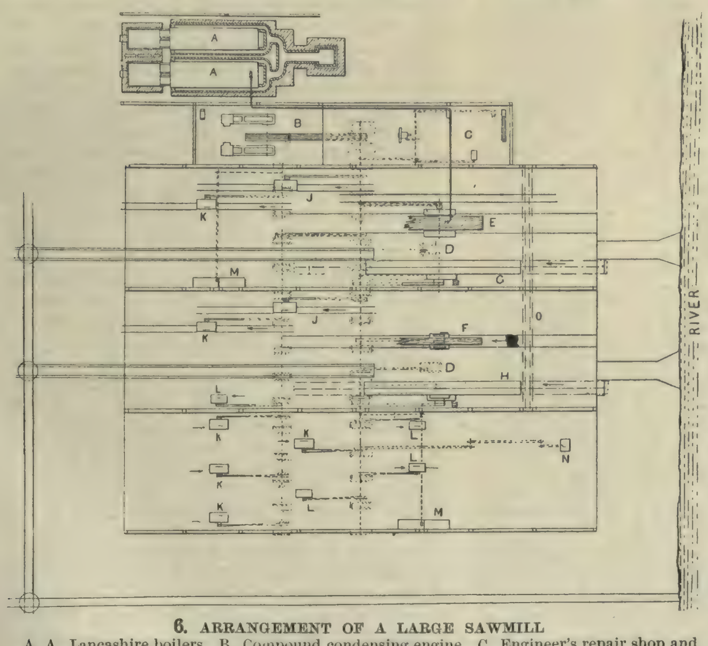
Although by far the greater number of mills are fitted with driving gear of the types described, the electric motor is tending to alter the existing state of things, and to do away with much of the shafting, belting, and expensive foundations required. The motors are mounted close to the machines, driving direct, or through the medium of belting.

A Railway Shop Sawmill. An excellent idea of the appearance of a sawmill may be gained from the photograph [1], taken in the Carriage and Waggon Department of the Midland Railway Company's works at Derby, and shown here by the courtesy of the superintendent of that department, D. Bain, Esq. A large quantity of timber is used by the company in connection with the production of carriages and waggons, and carts, drays, barrows, etc., including repairs. The average annual output is 5,500 new waggons and 200 carriages. A gantry is provided outside the mill, carrying two overhead travelling cranes, which pick the logs off the railway trucks, and set them on a cross-cut saw which cuts them up into suitable lengths. The mill, which has a floor space of about 10,000 square yards and is driven by engines developing about 800 I.H.P., has a cellar in which the shafting and belting are placed, in the manner previously mentioned. An overhead traveller is seen in the illustration, holding a short balk, and various circular-saw benches and frame-saws are visible. The aim in the design of the mill is to keep the timber moving in a straight line as much as possible from end to end, passing on the way to other machines that re-saw, plane, mortise, tenon, etc.

Figure 2 represents a rather different lay-out, and shows the interior of the sawmill of Messrs. Marshall, Sons & Co. The machine in the foreground is a horizontal band-saw, and a trolley track runs the length of the building for the easy conveyance of logs and sawn timber. The view illustrates the system of roof lighting and the loftiness of the buildings, a feature which is not always found in the average mill.



5. SIDE ELEVATION AND PLAN OF SAWMILL



6. ARRANGEMENT OF A LARGE SAWMILL

A, A. Lancashire boilers B. Compound condensing engine C. Engineer's repair shop and saw-sharpening room D, D. Log haulers E. 54-in. steam saw frame F. 24-in. vertical log frame G. 78-in. rack saw bench with 50-ft. tables H. 72-in. rack saw bench with 50-ft. tables J, J. 7 ft. 2 in. by 3 ft. 2 in. circular saw benches K, K, K, K, K, K. 6 ft. by 3 ft. circular saw benches L, L, L, L. 5 ft. by 2 ft. 6 in. circular-saw benches M, M. Swing cross-cut saws N. Shingle machine O. 6-ton travelling crab on beams

Continued

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A TRADE OF DEATH

Science and the Drink Question. Alcohol and the World. The Chief Factor of Death and Destruction. The Truth about Alcohol and Physique

By Dr. C. W. SALEEBY

NOTHING could be more unfortunate than that we should imagine sociology to be a kind of "high-falutin" series of speculations, which takes no cognisance of the actual life, its failures and successes, its joys and sorrows, of "a being such as man in a world such as the present." The desire to remove any such impression is one amongst many reasons which leads us at this stage to consider the question of the production, distribution and consumption of alcohol in modern civilised communities, with special reference to our own.

The Trail of Alcohol. This affords us, in the words of Dr. Sullivan, a writer who has lately made an extremely valuable contribution to the subject, "a study in social pathology." The social organism, like the individual organism, is subject to weakness, to disease, and even to death; though if we regard any society as but a unit in the structure of the *whole* society of man, we shall find it necessary to qualify this last statement. Now, the student of the diseases of society finds himself confronted at every turn with alcohol; his particular interest may be crime, insanity, feeble-mindedness, racial degeneracy, vice—but whichever it be, the trail of alcohol is over them all. It becomes necessary, then, for the truly scientific student to consider this common factor of all social diseases in as special and at the same time in as comprehensive a manner as may be.

The subject has a further educational value for us because to-day we may recognise in it the very best possible illustration of what we have already declared to be the peculiar character of sociology.

Sociology the Sum of all the Sciences. We saw that, like medical science itself on a lower plane, sociology depends upon other sciences which precede it in order of causation and in order of complexity. Sociology we declared to be the crown, the sum—nay more, the very synthesis of all the other sciences. Thus, to choose yet another illustration of this vastly important proposition, let us take the old biological quarrel of the inheritance of acquired characters. Lamarck and Weismann are not sociologists but biologists, and it might be that during the whole of the controversy between their supporters no word was ever heard of man nor, indeed, of any living creature, except, perhaps, sweet peas. Yet the issue of the controversy obviously is of the utmost importance to the sociologist, who is not a mere student of society as it is, but who has the future to serve. The whole theory and practice of education, the whole theory and practice of parentage, take on an entirely different aspect according to the answer returned to this question.

Now, the same is the case with the problem which we are about to consider. Sociology could, of course, study certain aspects of it at any time—even in the period of pre-scientific medicine; but, to state the issue in somewhat unqualified terms, is it not evident that the sociologist who believed alcohol to be a *necessary food* could never really have any common ground at all with him who believed it to be a *poison?* Is it not, indeed, obvious, when we come to think of it, that, let us say, the microscopical observations of the pathologist, working in the laboratory upon the minute study of the tissues of, perhaps, an intoxicated mouse, should make all the difference in the world to no less a person than the would-be philosophic student of social institutions, in whose eyes mice and microscopes are mere dirt?

An Epoch in the Drink Question. But, of course, the really philosophic student would not hold such an opinion; he would know the danger of calling anything common or unclean; he would realise the fundamental unity of life and the relevance of its laws throughout all its manifestations, low or high. And whilst he rightly regarded man as essentially a spiritual being, and society as therefore essentially a spiritual organism, he would yet remember that man is also an animal, subject to the laws of animal life, and that, if alcohol has a particular action upon the protoplasm of the tissues of a mouse—nay, even the protoplasm of the tissues of a fern—the fact is a fact *for him.*

Therefore, notwithstanding the common practice—or rather warned by the consequences of the common practice—of studying the alcohol question without having any knowledge of biological principles, and notwithstanding the possibility of encountering students who will say, "What on earth has all this to do with sociology?" we must begin our study of this subject by acquainting ourselves with such facts as the prior sciences can afford us. The full equipment for the study of this question involves months of hard reading devoted to the study of the basal, biological, or physiological facts—not to mention the pathological facts—ignorance of which would deprive our further efforts of almost all their value. This is very slowly coming to be recognised, and it marks an epoch in the history of the alcohol question.

Science and the Temperance Reformers. It always does mark an epoch in the history of any question when science is brought to bear upon it; when to goodwill is added knowledge. The earliest temperance

reformers corresponded in no small measure to the noble men and women who visited the fever-haunted gaols of not so long ago, moved simply by love, and who were the forerunners of modern criminology, which adds knowledge to goodwill and charity. The earliest temperance reformers had not knowledge, but they had the fundamental thing, which is goodwill. They witnessed the obvious evils of intemperance; they were stirred by noble emotions; and, futile though their efforts must have appeared, yet their emotional propaganda was the necessary beginning, as in all other cases, of the work which is being done to-day. In part of the course on Psychology we saw that emotion is the author of will; knowledge is merely its eye or pilot. And we, in a more scientific age, have no right to despise the pioneers for their ignorance. Had we lived in their time we should have been ignorant like them, and might have been inert and careless, as they were not. Not much longer shall it be ere, having armed goodwill with knowledge, love with science, we shall sing with Tennyson in "The Princess":

"Our enemies have fall'n, have fall'n: the seed,
The little seed they laugh'd at in the dark,
Has risen and cleft the soil, and grown a bulk
Of spanless girth, that lays on every side
A thousand arms and rushes to the Sun."

The End of Science is Truth. And here we need a warning. Our original motive may be curiosity or sentiment, and the goal towards which we aim may be the possibility of doing something, but in the intermediate stages we must be scientific if we can, and we must not permit ourselves the luxury of accepting a brief and trying to see how good a case we can make. The client of science is no person or party, and all victories other than the discovery of truth are defeats. We shall see that fanaticism, which renders good service and bad service in every cause, has done so in this; and whilst we may admire its sincerity we must absolutely repudiate its temper. First, then, as to basal facts, for which we have the positive evidence of the various sciences whose business it is to study them.

Here, perhaps, is some reward for the plan which the SELF-EDUCATOR has consistently followed. We may turn back from the study of sociology to the prior science of chemistry, and may recall the facts which were stated when we were studying it several months ago. On pages 3016 to 3021 we discussed the specific chemical and bio-chemical properties of alcohol. We alluded to the young science whose business it is to study the action of all kinds of chemical substances upon living matter. We discussed the relation of alcohol to the temperature of the body, its action upon nervous tissue, and we came to the conclusion that in general terms it is a food and a poison too.

Alcohol Does not Give Strength. The reader is asked to turn back to those pages before he proceeds with the question now before us. To what was there said let us add that various researches published since those words were written point more strongly than ever in the direction which they indicate. It is now actually dubious whether, even with the best intentions to do justice to alcohol, we can any longer admit its claim to rank as a food at all. Its structure tells us that it is incapable of making tissue, and it seems more than probable that, even when alcohol is taken in such a fashion that part or all of it is oxidised in the body, the oxidation does not yield energy which the body can utilise. Alcohol belongs in all probability to the class of "pure thermogens" (or heat-makers), as distinguished from true foods or "bio-thermogens," such as fats, carbohydrates and proteids, which become incorporated in the anatomical elements and supply their vital needs. Recent careful study of the whole evidence bearing on this question shows that alcohol does not serve as a source of muscular energy, "and that its use as a stimulant for work depends altogether on its excitant action on the psycho-motor centres, and has no relation to its food value." [The quotation is from a newly-published little book of the utmost interest and value, much of the wisdom of which has been transferred to these pages. Its title is "Alcoholism: A Chapter in Social Pathology"; and the author is Dr. W. C. Sullivan, of Pentonville. J. Nisbet and Co. 3s. 6d.] This excitant action of alcohol is transient and must be paid for. Furthermore, there will be found in Professor Metchnikoff's great work on "The New Hygiene"—which will probably appear by the time these words are published—conclusive proof that alcohol, in any dose, directly paralyses the protective white cells of the blood.

Science's Indictment of Alcohol. Thus, we now know where we are, so to speak. Half a century ago the sociologist, if he had attempted to make a sociological study of alcohol, would have found it difficult to contradict or to escape from the orthodox medical opinion of the time that alcohol is, except in the rarest possible cases, a necessary article of diet, and that any one who tried to do without it was a fool. The practical social problem of dealing with alcohol and the facts which it causes would have presented an entirely different character. The problem would have been to control, if possible, the abuses of alcohol, whilst at the same time extending its opportunities for usefulness. Thanks, however, in the first place, to the humanitarians, and also, of course, to the general progress of science, we stand now in a wholly different position. Essentially and properly, alcohol is a drug, and a poisonous drug. It is not needed by any healthy person; it tends to make more difficult the maintenance of health; its possibilities of use in disease are daily being more gravely questioned, the sole remaining one of any importance—that of its action in fever—having lately been proved false by authoritative and absolutely unbiassed witnesses, and the general study of the human race at large has shown that the alcohol problem is only the most important form of a more general one—the most important because it is

the form in which that general problem affects the most advanced and progressive nations of the earth.

English Alcohol is Worse than Chinese Opium. We now see that everywhere men employ narcotics if they can obtain them, and of such strength as they can obtain. We talk in horror-struck tones of the opium trade in China and we are aware of the enormous quantity of opium which is used in our own dependency of India. Blinded by familiarity and race-prejudice we do not realise that our own use of alcohol is precisely on all-fours with the use of opium in the East; except that the ravages of alcohol are immeasurably worse, there is nothing to choose between the two cases. It is a fact of the human constitution that in general it finds attraction in the use of narcotics. Usually one narcotic serves its turn.

In general, the races which use opium do not use alcohol, and those which use alcohol do not use opium ; but there is not the smallest scientific distinction between the public-house and the opium den. The fundamental biology and physiology of the two cases are one and the same, and a visitor from some older planet, which had reached a higher stage of progress than any we have yet attained on the earth, casting an impartial eye upon China and England, and in his wisdom allotting no hasty blame to either country, would certainly say that the English vice was worse than the Chinese. It strikes our self-satisfied minds as a piece of impertinence that Japanese or Chinese of great advancement should propose to send missionaries to England in the attempt to cure us of our alcoholism. They have even more reason to do so than our humanitarians have reasons to make efforts to control the use of opium in China. There is no worse bias than the bias of race, and there is no more pitiable illustration of it than the present case affords.

A Blackguardly Trade. Since we are attempting to take a wide view of this subject it is necessary for us briefly to consider the relations of alcohol to the advancing borders of civilisation. This multiplication and dissemination of the civilised peoples is, of course, a great world-fact to which alone a sociological genius might devote many lifetimes. In general it involves the destruction and disappearance of lower races. This is the fact, our present concern being not to pass any judgment upon it but to recognise it. The main agents of this destruction are the diseases unintentionally introduced by the missionary and the alcohol intentionally introduced by the trader. This last is one of the most blackguardly and abominable kinds of trade which any history could conceivably record. The natives have hitherto been able, in their ignorance, to brew liquors containing only very small proportions of alcohol; but the trader brings them raw whisky or even potato-spirit—the reader of the course on Chemistry will remember the sequence: potato, starch, sugar, alcohol. Both in the case of the missionary's consumption and the trader's whisky there is introduced into the environment of the native a new factor against which he has hitherto undergone no evolution. Natural selection has done nothing to eliminate the susceptible. No gradual immunity has been acquired by the individual—as many of us probably acquire a gradual immunity against tuberculosis or consumption—and the consequence is wholesale slaughter. Observe that we are passing no judgments as to whether this may or may not be the shortest way out of a terrible difficulty, though for ourselves we are very strongly convinced that it is not. At any rate there is the fact. The greatest student of this remarkable question is Dr. Archdall Reid, to whom all serious thinkers are deeply indebted for his courageous and single-handed efforts to establish facts of such great importance. But most important for us is, not the action of alcohol at the advancing borders of civilisation and its terrible efficiency as a means of advance—if such advance be really advance—but its action within the acknowledged territories of civilisation itself.

The Three Reasons for Drinking. And here let us follow Dr. Reid, and clear the issue by beginning at the beginning. Alcohol is manufactured in response to demand. It is true that under present conditions, which are essentially false, everything is done by those interested in gratifying the demand in order to stimulate it and make it even more urgent than it would otherwise be. But the fact remains that the demand exists, in the first place, just as the demand for opium exists amongst Eastern civilisations. Now, in the case of opium there is no confusion as to the demand for it. It is used because of its action upon the nervous system. In the case of alcohol the issue is confused, and more's the pity. Let us make it clear, then, that "men drink alcoholic solutions for three distinct reasons—to satisfy thirst, to gratify taste, to produce a direct effect on the brain." "But, though men drink for three separate reasons, it must not be supposed that all drinkers are sharply separable into three distinct categories. The same man, at the same time, may drink to satisfy his thirst, his palate, and his craving for drunkenness. Or at first he may desire to satisfy his thirst, next to gratify his palate, and lastly he may seek for intoxication. Or again, at the beginning of his drinking career he may drink primarily to satisfy his thirst or taste, and, at the end, primarily to gratify a craving for intoxication. The fact remains, however, that, while many men drink merely to satisfy thirst or taste, the principal motive with others is to obtain those feelings of intoxication [or organic satisfaction] which alcohol produces when acting, in considerable volume, directly on the central nervous system." ("Alcoholism: A Study in Heredity." By Dr. Archdall Reid. Fisher Unwin, 1901.)

The Price Man Pays for Pleasure. Now with the first two kinds of drinking we have no concern here. They are not of the smallest importance, except because of their extreme liability to lead to the third kind. The thirst can be gratified without alcoholic beverages,

and, as a fact of physiology, is a thousand times better so gratified. The gratification of the sense of taste is almost the lowest form of physical pleasure, and there is, of course, no distinction between the connoisseur who enjoys his fine wine, the smoker who—like the present writer, who has no bias—enjoys a good cigar, and the hog who enjoys the flavour of a well-mixed hog wash. The gratification of the sense of taste is not to be condemned as improper, but when the lives and souls of men, women, children, and civilisations are involved, interference with such gratification is the most trivial of all trivial circumstances, Practically, then, we are entitled to regard alcohol as a narcotic drug which, like other narcotic drugs, exercises attractive (though transiently attractive) properties upon the human organism. Subsequent consequences are more or less undesirable, but, as moralists in all ages have observed, it is a difficult matter for man to resist the immediately pleasurable, even though he knows that he must afterwards pay an inordinate price for it.

The Rubbish about Alcohol for Women. The social results of alcoholism, of course, depend upon its individual results, and the character of these is now beyond dispute. When it was discovered how to make an exceptionally strong alcoholic solution, the name of *aqua vitæ*, or water of life, was given to it. We now know that the proper name for such a fluid is *aqua mortis*—water of death. The nursing mother may still be ordered stout and porter as aids to her great function. We now know that nothing produces milk like milk itself, and that the alcohol taken by such a mother passes in her milk to her child, in whom it may produce lamentable consequences—none the less lamentable because not obvious. It is our business here to brush all this rubbish aside, and to estimate as best we may the social consequences of this drug, which we have already stated to be involved inextricably in what are called the diseases of society. But first of all let us deal with physical disease.

The Registrar-General reports the percentage of deaths due to alcoholism as about 1 in 20,000. This means nothing at all, except that before you begin to interpret death certificates, it is well to know the conditions under which they are filled up. It is extremely probable that even "the highest estimates, based on medical returns, fall short of the actual truth," but even if only 120,000 deaths—a modest estimate—annually result from the use of alcohol, this means about one-sixth of all deaths, including the infant mortality.

Alcohol Makes the Bed of Consumption. The proportion, then, even on this very moderate estimate, would be much more than twice as great as the death-rate due to the most deadly of all other known diseases, which, of course, is tuberculosis. The great French physician, Landouzy, has said that alcoholism makes the bed of tuberculosis. In patients dying of alcoholic neuritis, four out of five are found to have consumption. Leading authorities both in France and in America estimate that about one-half of all cases of tuberculosis—which kills 60,000 persons in this country every year—are due to alcohol. Exceedingly interesting questions arise, of course, as to the exact relation between the drug and the disease. They do not here concern us. The outstanding fact is that, apart from all deaths due directly to morbid tissue changes caused by alcohol, we must include every year, in our own country alone, tens of thousands of deaths which are returned as being due to tuberculosis. To these would have to be added an enormous number of deaths due to pneumonia or inflammation of the lungs, which is much the most deadly of all acute diseases.

The Appalling Death-roll of Alcohol. Again, there would be a large number of deaths due to various vicious diseases, in the causation of which alcohol is a most important factor. Indeed, it is impossible to question the now long-proved fact that in what is commonly regarded as the normal, reasonable, respectable death-rate of such a community as ours this utterly unnecessary, artificial, and man-made factor of alcohol far outweighs, directly or indirectly, all other factors put together. We have said nothing here as to the appalling relation between alcoholism and infant mortality, but, of course, an entire book would be necessary adequately to state the indictment of alcohol in its relations to death, and the sooner some highly competent student writes a book upon "Alcohol and Death" the better.

A leading London paper has lately published a long letter from which the latter part may be quoted in full. It represents in its most perfect form an argument, the unspeakable imbecility of which the most ignorant critic can recognise but the greatest literary genius could not adequately express:

"Sir,—The licensed trade, in which I am not engaged, and the customers of the licensed trade, to whom I do belong, are useful citizens. They contribute enormous sums to our annual revenue in income tax, excise, and many other ways. I need not quote figures, but if I spend £10 a year on beer, the State gets at least £1 12s. out of it, and the teetotaller, who pays no contributions of this sort at all, receives the benefits, and considers himself socially and morally a superior being. The liquor trade may be wealthy, but it has enormous burdens, and sensible people will remember that so long as the proverbial goose is treated after the manner of other fowls, we may expect a continuous supply of his valuable eggs. The senseless fanaticism that would rip him up should be opposed with the utmost energy in Parliament and in the Press by all practical persons who have the commercial interests of the country at heart."

Alcohol and the Race. We shall return later to this incomparable masterpiece. That anything articulate should be capable of such folly is as remarkable as any fact on record. The mere drivelling of insanity is the pearl of great price compared with it. Meanwhile, we may briefly note that distinguished French publicists estimate the annual cost of alcoholism

to the French State in scores of millions of pounds. In making any such estimate it is, of course, the death-rate that would furnish the first item. But on any reasonable estimate of the average monetary value of a life this first item could not figure nearly so large as others which would follow it If alcohol killed as a man is killed by a motor-car accident, then the alcoholic death-rate might furnish something like an index of the cost of alcohol to the State. But that, of course, is not its method, and the significance of the difference cannot be measured.

Still confining ourselves to the physical consequences of alcoholism—in so far as it is possible to make a distinction between the physical and the psychical aspects of a drug which acts on the organs of mind—we must now approach the important question of the action of alcohol upon the physique of any race.

The Poisoning of the Germ of Life. It was specially with reference to this approaching question that we referred to the biological controversy concerning the inheritance of acquired characters. The common-sense view was long held that the children of a drunkard would be apt to start life with an injured endowment. Then there was advanced the famous "germ-plasm" theory of Weismann, and the categorical and dogmatic denial that acquired characters can be transmitted by inheritance. In their eagerness to prove the impossibility of such transmission, many of the followers of Weismann—including even Dr. Archdall Reid, who seems to most of us so accountably astray on this question—have declared that the old common-sense view is a myth. They incline to suppose that the germ-plasm is inviolable—nothing can touch it. Whatever accidents or disasters or diseases may affect the parental organism, the germ-plasm, of which it is the host, passes on unscathed from generation to generation.

Such ludicrous statements, due to excess of zeal, clearly prove how excess may confuse even acute minds. The transmissibility of an acquired character, which Lamarck asserted, and Weismann denies, is utterly distinct from, let us say, the poisoning of the germ-plasm by alcohol.

The Soaking of the Germ-plasm in Alcohol. There is certainly no conceivable means by which the much-used biceps of the blacksmith can affect his germ-plasm so that his child will start life with a bigger biceps than he would have had if his father had been a clerk. But just as such a process is inconceivable, so it is inconceivable that a poison, circulating in every tissue of the body, present alike in the blood and the lymph, *should fail to injure* the germ-plasm which depends upon that blood and lymph for its life. Suppose that the persistent application of alcohol to a finger-nail caused it to become horny, that would be an acquired character which could not thinkably be reproduced in the germ-plasm; such reproduction would be a case of Lamarckian transmission of an acquired character. What on earth has this case to do with the actual soaking of the germ-plasm itself in a solution of alcohol?

When we clearly analyse the facts we see that the consequences of the application of any other poison, or a crowbar, or half a brick, to the germ-plasm have no more to do with theories of heredity proper than they have to do with the authorship of the Pentateuch.

Alcoholism and Parentage. The study of heredity, and all the theories of it, are concerned with the manner in which the young organism tends to resemble or to differ from its parent in virtue of the inherent laws and properties of living matter. The question of the applications of poison to the germ-plasm, or to the fertilised ovum, or to the child before birth, or to the child after birth, is a vastly important inquiry, but it is no proper part of the actual study of heredity, and the facts which are elucidated in the study of this question are utterly independent of the opposed theories of heredity. Of course, if the upholder of the theory of the continuity of the germ-plasm imagines it to mean that the germ-plasm could not be pulverised by a steam-hammer, or killed by prussic acid, or killed or injured by alcohol—well, then, so much the worse neither for the theory nor the fact, but for his intelligence.

We may turn, then, to the study of the social facts, untrammelled by any theories or counter theories of heredity, or, rather, we may thank the latest and most brilliant theory—that of Weismann—for presenting the facts in such a manner that any escape of the germ-plasm from alcohol contained in the blood which nourishes it is unthinkable.

The Children's Curse. What, then, do we find? We have no choice but to believe that the effects of alcohol extend to the next generation. It may be, and not infrequently is, that the alcoholic is already a degenerate, and since he is so, his children will also be degenerate, alcohol or no, and being degenerate, will very likely become alcoholic. But vastly excessive importance has been attached to inborn degeneracy as a cause of alcoholism. Proof of this is easily to be found in Dr. Sullivan's study of Industrial Drinking, in the invaluable book to which we have already referred. No one who knows anything about it imagines that, as a rule, or even in one case in a hundred, the alcoholic labourer was a degenerate from his birth; but there is every reason to believe that his children may be made degenerate from their birth. Products of germ-plasm bathed for years in alcohol, what else could be expected of them?

Continued

HYDRAULIC POWER

The Industrial Application of Water Power to Mechanical Appliances. Typical Examples of Hydraulic Apparatus

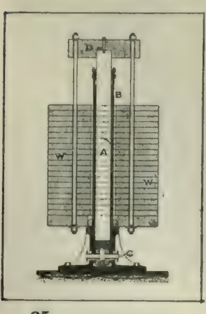
continued from page 5580

By Professor HENRY ROBINSON

Hydraulic Power. In utilising water pressure for power purposes we shall first consider the subject in regard to the employment of water pressure in mains by the artificial aid of pumping engines before treating of the natural pressure due to heads of water in reservoirs or waterfalls. The facility with which water under pressure can be transmitted to great distances was first recognised by the late Lord Armstrong, and resulted in the system being adopted in numerous railway depôts, docks, etc., and afterwards in many towns, one of which was Hull, where the writer carried out the first scheme of public supply of water pressure under an Act of Parliament; and this has been followed by similar installations in many towns in England and abroad.

Hydraulic Pressure. The pressure in the mains is obtained by pumping water at a central station against a weighted "accumulator," which gives the artificial head according to the load in it. The accumulator consists of a cylinder containing a ram, the top of which either carries a cross beam, to which is suspended an iron case filled with the weighting material, or a series of weights are attached to a cylinder outside the ram. As the water is pumped into the cylinder (the mains being filled) the ram rises to the top of its stroke, and if the water that is drawn off from the mains to work the machines that are actuated by the water pressure is less than that which is being pumped into the accumulator, the engine is automatically stopped by means of a chain connecting with the steam throttle-valve of the engine, and water ceases to be pumped into the accumulator.

Figure **35** illustrates an accumulator made by the Hydraulic Engineering Company. The water is pumped into the cylinder B through C, raising the ram A, to which is fixed the cross beam D, carrying the weights W. A means of intensifying the pressure is afforded by an arrangement such as that shown in **37**.



35. HYDRAULIC ACCUMULATOR

Low-pressure water is conveyed through the pipe A into the cylinder B, in which is a piston, and the pressure exerted on it is transmitted by the small ram D to the water in the second cylinder E, giving an increased pressure in proportion to the areas of the piston C and the ram D. The water from the pumps, for power purposes, enters through the inlet G and passes out at H to the machine to be worked by it. No water is consumed from the low-pressure cylinder; it is simply driven back by the force pumps into a low-pressure accumulator or main.

Besides the artificial head which an accumulator produces, it also acts as a storage of energy. For instance, an accumulator with a ram 12 in. in diameter, and with a stroke of 22 ft., when at the top of the stroke, and with water at a pressure of 750 lb. per square inch, stores the following amount of energy:

Area of 12 in. ram = 113·097 sq. in.

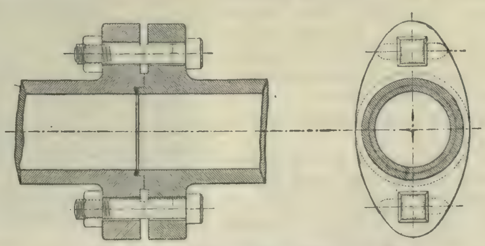
Energy stored = 113·097 sq. in. × 750 lb. × 22 ft. = 1,866,150 foot lb.,

$$\therefore \frac{1,866,150}{33,000} = 56{\cdot}5\text{-horse power acting for one minute.}$$

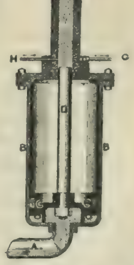
The combined efficiency of the hydraulic pumping engine and the accumulator varies from 80 per cent. at slow speeds of working to about 70 to 75 per cent. at high speeds.

High-pressure Water. The transmission of high-pressure water is usually at a velocity of about 3 ft. per second, but higher velocities are possible, as thereby the power transmitted in a unit of time is increased. For instance, at a velocity of 6 ft. per second the power transmitted would be double that of 3 ft. per second.

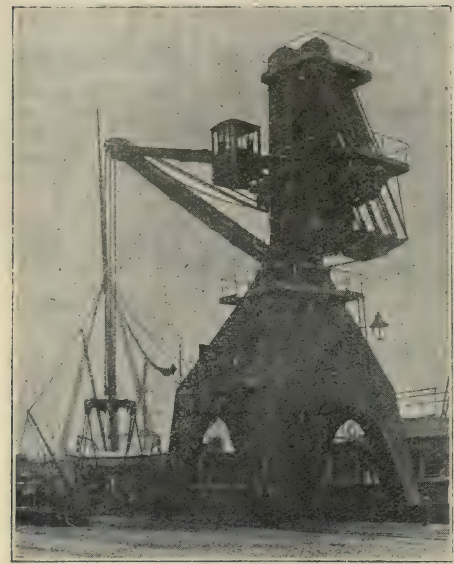
Where cast-iron mains are used, the internal diameter is generally from 6 in. to 7 in. Steel tubes are employed with larger diameters. One 12 in. in diameter has been employed to convey water at a pressure of 750 lb. per square inch. The advantage of the larger pipe is that if a 6-in. main



36. JOINT FOR HYDRAULIC MAIN



37. HYDRAULIC INTENSIFIER



38. MOVABLE HYDRAULIC CRANE

will transmit a certain gross horse-power at a given pressure, a 12-in. main would transmit four times the horse-power at the same pressure.

The best manner of jointing hydraulic pipes has been the subject of much practical experiment. A gutta-percha ring has been adopted as the best means for preserving a watertight joint. Where hydraulic mains are exposed to heat, leather rings should be employed. Figure 36 shows the method of jointing a 5-in. hydraulic main.

Mr. Ellington has designed a modified form of this joint by putting a projection on the pipe beyond the flange, the spigot and faucet being formed on this projection. The effect is to increase the depth and the strength of the flange without an increase of its section at the junction between the flange and the pipe.

Loss by Friction. The loss of pressure due to friction in the mains may be taken as insignificant in the case of high-pressure systems. With low-pressure water the loss is more appreciable. The writer's book on "Hydraulic Power and Hydraulic Machinery" deals fully with the numerous purposes to which hydraulic power is applied. It must suffice here to enumerate the principal ones. They are cranes, goods hoists, jiggers, elevators, lifts, swing bridges, dock gates, sluices, capstans, shop tools, pipe welding, plate bending and flanging, forging, shearing, riveting, drilling, presses, excavators, pile sinking, working guns on men-of-war and land defences, machinery on board ship, etc.

The advantages of a system of power distribution by water pressure have long been recognised. It should, however, be noted that all machines or motors worked with it consume the same amount of water, whether they are loaded to the full capacity of the apparatus or only partially so.

Hydraulic Apparatus. Figure 38 is one of Sir W. G. Armstrong, Whitworth & Co.'s, Ltd., movable hydraulic cranes for shipping coal direct from trucks, and 39 is a coal-tipping hoist made by the same firm.

In 40 is shown one of the Hydraulic Engineering Co.'s double power jiggers, as employed for suspended lifts, cranes, etc.

Figure 41 is one of Messrs. Bailey & Co.'s hydraulic capstans. The capstan is set in motion by pressing down the knob P with the foot.

An illustration of the employment of hydraulic machinery in the form of a crane on board ship is given in 42.

It is impossible in this course to refer to all the different shop tools and machines employed in workshops. A few types will, however, be given.

Figure 43 shows a "Fielding" portable riveter in combination with a hydraulic chain lift. The latter may be suspended from a travelling crane hook or from any fixed point. The combination shown represents a double-powered 40 and 20 ton machine of 42 in. gap, with compound hanger. The lift has a range of 5 ft., and can lift $2\frac{1}{2}$ tons. A portable riveter at work on a boiler is illustrated in 45.

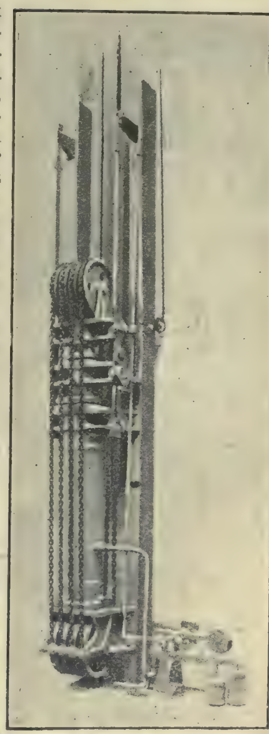
A good example of a hydraulic-forging press is shown in 44. The pressure on the main ram is equal to 100 tons, and to 75 tons on the horizontal, and 50 tons on the stripping, ram.

39. HYDRAULIC HOIST

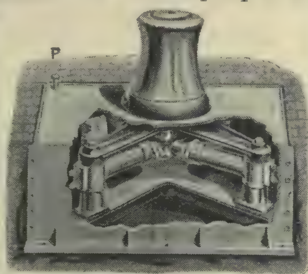
Figure 46 shows an Armstrong hydraulic fire appliance for use on quays, docks, etc.

Hydraulics in Tubular Railway Construction. The "shields" employed for constructing the tunnels on the Baker Street and Waterloo Railway are shown in 47. They were moved forward by hydraulic presses or rams. Within the main body of the shield, behind a circular girder, was a cast steel ring bearing fourteen hydraulic rams, R, 6 in. in diameter, and arranged as shown on the figure. The lowest four rams were not always brought into use, as ordinarily the remaining ten were sufficient for driving the shield forward. Each ram was capable of being operated independently. The stroke of the rams was 20 in., and the water power (supplied by the London Hydraulic Power Company at about 800 lb. per square inch) was intensified, so that the average pressure for driving the rams was about 1,300 lb. per square inch. The illustration is from a paper read by Messrs. Copperthwaite and Haigh before the Institution of Civil Engineers.

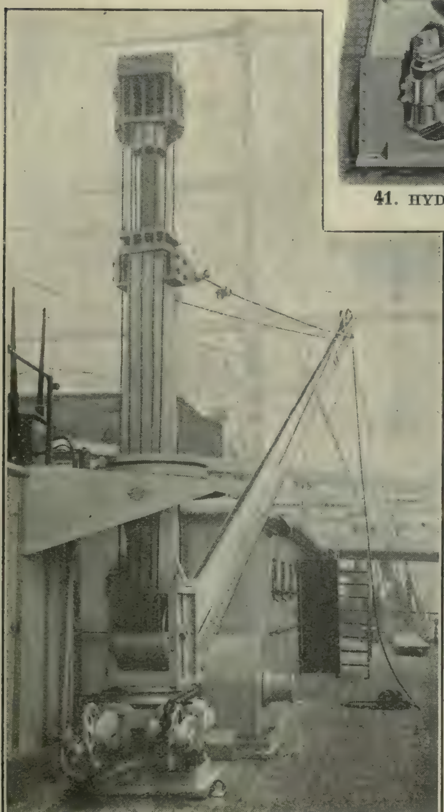
The Hydraulic Jack. This useful appliance is illustrated in 51, which shows one made by Tangyes, Limited. This jack forms a combination of the hydraulic press and pump. A ram, A, resting on a footplate, carries on the top a cylinder C, to which is attached the combined press and pump in the chamber B. Water is run into the chamber or reservoir B by a charging hole at the side. A lever attached to a spindle at D enables the short crank E of the force-pump of the press to be raised and lowered. Water is drawn into the pump cylinder (through a suction valve) from the reservoir at the up-stroke, and is forced by the down-stroke on to the head of the fixed ram beneath, by which the cylinder and the load resting on the top of the press that is carried by it are raised. When the jack is at work a small screw in the side of chamber B is slackened to allow air to pass in and out. The force produced is due to the leverage brought to bear on the plunger of the pump acting on a small area, and thence to the larger area, of the ram. The weight capable of being lifted can be calculated as follows:



40. HYDRAULIC JIGGER



41. HYDRAULIC CAPSTAN



42. HYDRAULIC SHIP CRANE

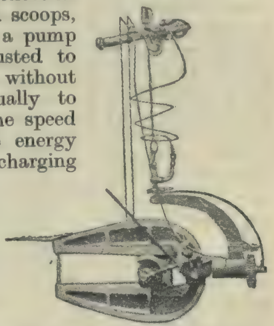
$$W = \frac{A}{a} \times \frac{L}{l} \times P,$$

where W = weight to be raised,
A = area of ram,
a = area of pump,
L = length of lever,
l = length of pump crank,
P = pressure exerted on handle in pounds.

The efficiency of hydraulic jacks has been ascertained from experiments to be about 77 per cent.

Hydraulic Pumps. Figure 48 shows a portable hydraulic hand pump. This is frequently useful for testing water mains, etc.

Some lifeboats are propelled by a centrifugal pump on the hydraulic system, thereby dispensing with screws or paddles, which are liable to injury from floating wreckage, or by striking the bottom. The motive power is that of jets produced by the collection of the sea-water in scoops, which deliver it to a pump having vanes adjusted to pick up the water without shock, and gradually to accelerate it to the speed of discharge, the energy being utilised by discharging the water through nozzles to orifices in the vessel above sea-level. The jets are controlled by handles on deck, and can be directed either ahead or astern, so that the vessel can be managed by the jets, although it has a rudder and stearing gear. Although the efficiency of this form of propulsion is only about one-half that of screw propulsion, nevertheless the freedom from the before-mentioned dangers has led to its adoption.



43. PORTABLE HYDRAULIC RIVETER

We shall next deal with the utilisation of water power which is available from natural sources. The machines which are employed to convert the head of water due to the slope of a river, or a waterfall, into power are water-wheels and turbines.

45. HYDRAULIC RIVETER

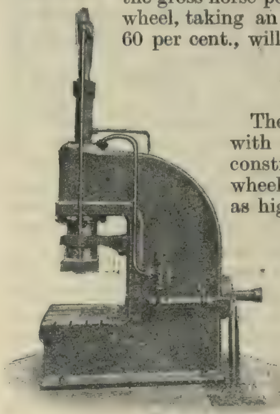
Water-Wheels. Water-wheels may be classified under three headings — namely, *overshot*, where the water is received in buckets at the summit of the wheel; *breast*, where the water is received below the summit; and *undershot*, where the water acts by momentum at the bottom of the wheel.

The variation of level of the water determines the kind of wheel to be adopted at any particular place where the water power is proposed to be utilised. In all three wheels the power due to water flowing from a high to a lower level acts on a wheel revolving on an axle either by its weight, as with the overshot and breast wheels, or by its momentum as with an undershot wheel.

46. HYDRAULIC FIRE APPLIANCE

Overshot Wheels. In wheels of this kind the power acting on the wheel is due to the volume of water received in the buckets, and the height through which it falls. If F represents the fall in feet, and Q the weight of water received in the buckets in pounds per second, then the gross horse-power acting on the wheel, taking an efficiency of only 60 per cent., will be:

$$\frac{Q \times F \times 60}{33{,}000}$$



44. HYDRAULIC FORGING PRESS

The efficiency varies with the design and construction of the wheel, and has reached as high as 75 per cent. in overshot or breast wheels.

In ordinary overshot wheels the buckets are shaped so as to prevent the water shooting over the wheel. This is obviated by making the capacity of the bucket three times that of the volume of water discharging into it.

Breast Wheels. With wheels of this type [**50**] the water is received from a channel surrounding the wheel, on the vanes below the summit —generally between the axis and the lowest point. The water thus acts by its weight in turning the wheel, the efficiency being about 65 per cent., although 75 per cent. has been attained by breast wheels well designed and constructed.

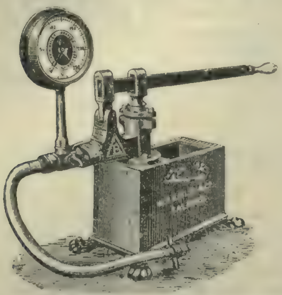
Undershot Wheels. In this class of wheel [**52**] the water acts on the vanes by its momentum at the bottom. When small falls of 6 ft. or so, or rapid currents, have to be utilised, this type of wheel is best. The water impinging on the "floats" imparts a portion of its energy to turning the wheel, but eddies involve much loss of power.

By comparing **50** and **52** the difference between the bucket of a breast wheel and the vanes of an undershot wheel will readily be seen.

The "Pelton Wheel." This type of wheel [**49**] is much used in America. Cups are attached to the circumference of the wheel. The water is delivered through a nozzle, N, and strikes the cups, B, in the middle, so that the whole of the energy is exhausted, as the water is deflected and spreads over the cup.

The Chinese (or "Scoop") wheel is used for low lifts, and is practically an overshot wheel with reversed motion. Water is caught in

buckets as the wheel revolves, and is raised to a height nearly equivalent to the diameter of the wheel. This kind of wheel is employed for draining fen lands.



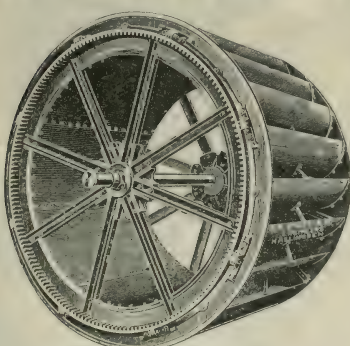
48. HYDRAULIC TESTING PUMP

Turbines. Water power is utilised in a turbine by the water passing from a high to a lower level through guide blades in a fixed case, producing rotary movement, due to the water acting on a revolving wheel after it has acquired a definite velocity while passing through the guide blades. The revolving wheel receives the water without shock, and after it has expended its energy in driving the wheel the water passes away into a tail race, with only a very small loss of energy. The turbine is a most economical appliance for utilising a natural fall of water for power distribution purposes.

Turbines are classified into "radial," "axial," and "combined." In the radial type the water passes through the wheel at right angles to the axis of rotation. In axial turbines the water flows through the wheel parallel to the axis of rotation. In some turbines these two are combined.

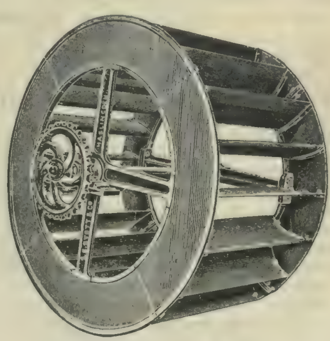
47. SHIELD USED IN CONSTRUCTING TUBULAR UNDERGROUND RAILWAYS

A "reaction" turbine works with all the parts under water, and this is a good type for small, or varying falls.



50. BREAST WHEEL

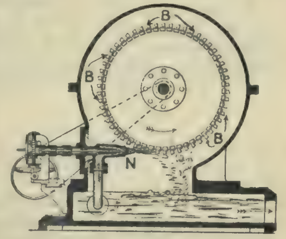
51. HYDRAULIC JACK



52. UNDERSHOT WHEEL

"Impulse" turbines have the buckets only partly filled with water. This type is not so good as the "reaction" for low or varying falls. In both there are guide blades to direct the water at its entry to the buckets of the wheels.

Experiments have proved that turbines have a far higher efficiency than water wheels with low falls.



49. PELTON WHEEL

Waterfall Power. Attention is being more and more directed to the importance of utilising the enormous amount of power that exists in natural waterfalls. One of the best known is that of Niagara, where a fall of from 140 ft. to 160 ft. is available, and is partly employed in working turbines for the distribution of power for industrial purposes, for working electric street railways, to mechanical power, and to electric lighting, for a distance of forty miles or more. The magnitude of this enterprise may be realised when we mention that the centres of power production develop from 50,000 to over 100,000 horse-power by means of turbines of 5,000-horse power, and some are being constructed of 10,000-horse power.

In England, waterfalls are being utilised on a large scale compared to the old corn or other mill, where a waterwheel or turbine enabled the flow of a stream to develop a useful amount of energy.

A step in the right direction was taken when the British Aluminium Company utilised the falls of Foyers, above Loch Ness in the Scottish Highlands.

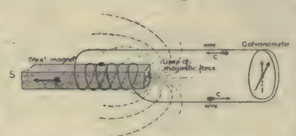
HYDRAULICS *concluded; followed by* PUMPS

TRANSMISSION OF SPEECH

Invention of the Telephone. Receivers, Transmitters and Switches. The Telephone Exchange and its Complicated Mechanism

By D. H. KENNEDY

OF the many inventions which distinguished the latter half of the nineteenth century, it is safe to say that none excited greater wonder and interest than that of the Telephone. It was looked upon as the first step in the direction of realising the "Arabian Nights" dream of a magic carpet—the brilliance of the conception cannot easily be realised. For thousands of years men had been content to transmit their speech sounds over at most but a few hundred feet. In 1876 Graham Bell astonished the world by showing how the energy of sound vibrations could be transformed into electrical energy, transmitted along a wire at a speed approximating to that of light, and re-transformed into sound waves under conditions which seemed to annihilate all the pre-existing limitations of time and space. When we remember that sound in air travels at about 1,100 feet per second—a speed which would require over half an hour to traverse the distance between London and Glasgow—and at the same time know that every day men converse between these towns as easily as if in the same room, we appreciate more fully the modern miracle of the telephone. As has occurred with many other epoch-making inventions, so in this case all the necessary component parts were in existence, and only the touch of genius was required for a great forward step.



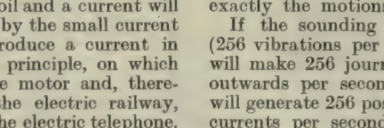
1. FARADAY'S EXPERIMENT

The Dawn of the Electric Age. Faraday had shown, in 1831, that the increase or decrease of the number of lines of magnetic force interlinking with a conducting electrical circuit was always accompanied by the production of a current [see 1].

These lines of force, although only partly shown, form closed curves, each traversing a path partly in the steel magnet and partly in the space surrounding it. When the coil is placed on to one end of the bar magnet, as shown in the sketch, it interlinks with nearly all the lines of force. If the magnet is then withdrawn, as indicated by the large arrow, the lines of force will cut the coil and a current will circulate in the direction given by the small current arrows. Its reinsertion will produce a current in the opposite direction. This principle, on which are based the dynamo and the motor and, therefore, the electric light and the electric railway, formed also the foundation for the electric telephone. Philip Reis, in 1864, had nearly solved the problem. He constructed an apparatus with a movable diaphragm sufficiently elastic to reproduce all the vibrations caused by the voice. This plate was intended to open and close the circuit of a battery, and the intermittent current so produced was conducted by a wire to a recei er consisting of a coil containing a rod of iron, the rapid changes in the magnetisation of which produced a tone.

Bell's Invention. Reis's instrument had been able to transmit music, but was not suitable for spoken words. His instrument transmitted currents corresponding in number per second to the pitch of the originating sound, but not varying with the timbre or intensity of these sounds. This deficiency Bell supplied by the simple expedient of providing a horseshoe-shaped permanent magnet with a coil of wire on each pole, and fixing in front of it a flexible iron diaphragm. The lines of force emanating from the magnet link with the coils and crowd into the thin iron disc. Owing to its greater permeability for such lines, the thin slip of iron offers a path equal to 2,000 to 3,000 times its thickness of air. This fact makes it the determining factor in fixing the path of the majority of the magnetic lines, and consequently every change in the position of the diaphragm varies the position of the lines of force. It also varies the number of such lines interlinking with the coils; and it will be remembered that this is the condition which Faraday showed resulted in the production of an electric current.

Graham Bell constructed two such instruments and connected them by wires as shown in 2. Let us suppose that the diaphragm at A is thrown into vibration by impinging sound waves. As it moves nearer to the permanent magnet, a current is produced and transmitted to the instrument at B. We may suppose it to be in such a direction that the field produced by the coil at B will be added to the existing permanent field of the magnet. It follows that the tractive force will be increased and that the diaphragm will be drawn inwards. Meanwhile, the diaphragm at A swings outwards. This produces a current reverse in direction to its predecessor, and its effect on reaching B will be to produce a field which will oppose and reduce the field of the permanent magnet. As a result, the diaphragm at B now swings out, thus following exactly the motions of the sending diaphragm.



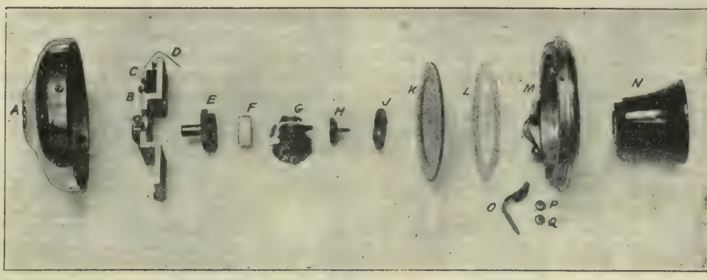
2. GRAHAM BELL'S TELEPHONE CIRCUIT

If the sounding body be emitting the note C (256 vibrations per second), then each diaphragm will make 256 journeys inwards and 256 journeys outwards per second, and the sending telephone will generate 256 positive currents and 256 negative currents per second, using positive and negative to indicate direction. It should be noticed that the receiving diaphragm lags in phase by a quarter of a period. For instance, the maximum value of the current, which produces and is coincident with the *maximum displacement* at the receiving end, occurs when the diaphragm at the sending end is passing through its position of *zero displacement*. In this simple arrangement, completely reversible in its action, we have an efficient means

of communicating spoken sounds over considerable distances.

The Receiver. Bell's telephone remains with us in the form of the receiver, the part of the modern instrument which is held to the ear. Although identical in principle, every detail of its electrical and mechanical features has been brought to a high state of perfection. The form shown [3] has a horseshoe-shaped permanent magnet $3\frac{1}{4}$ in. long, and soft, iron pole-pieces on which are mounted two oval-shaped coils of silk-covered copper wire, each coil having 700 turns and a resistance of 30 ohms. A specimen recently examined had $\mathbf{N} = 2{,}000$ for the permanent magnet and $\mathbf{B} = 5{,}600$ for the diaphragm, which is 5·5 centimetres in diameter and ·025 centimetre thick. This value of $\mathbf{B}$ is suitable for producing a large movement with a relatively small current [see page 560].

The case is of ebonite, or brass with an ebonite shield, and the mechanical connection between the magnet and the case is made as near to the diaphragm as possible, so that when once adjusted at a distance of about $\frac{1}{32}$ in. from the poles it will not be disarranged by temperature variations. The ear-piece is arranged to clamp the diaphragm in position.

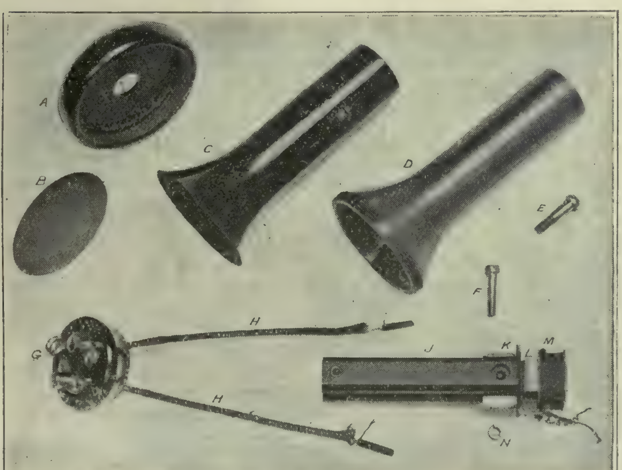


4. DISSECTED SOLID-BACK TRANSMITTER

A. Brass basin which with *M* forms the case of the instrument. *B*. Brass bridge which is screwed to *M* and supports *E*, *F*, *G*, *H*, and *J*. *C*. Terminal for wire leading to front electrode (*H*) mounted on ebonite. *D*. Thin wire, end of which is soldered to top of *H*. *E*. Hollow cylinder of brass containing rear electrode of carbon. *F*. Strip of paper which fits round interior wall of *E*, insulating it. *G*. Carbon granules to fill *E*. *H*. Front electrode of polished carbon which fits into top of *E*. A thin washer of highly flexible mica (not visible) closes edges of *E*, and prevents escape of granules. *J*. Dished screwed washer, which clamps edge of mica when screwed on to *E*. *K*. Aluminium diaphragm, $2\frac{1}{4}$ in. diameter with hole at centre into which screwed pin of *H* fits. It is surrounded by a soft rubber band. *L*. Ring of mica interposed between *K* and *M*. *M*. Front of case with one of the damping springs which normally presses against inner side of *K*. *N*. Ebonite mouthpiece which screws into *M*. *O*. Second damping spring. *P* and *Q*. Nut and check nut which screw on to pin of *H* on remote side of diaphragm (*K*), so connecting *H* and *K*.

The Transmitter. It was soon found possible to improve the sending end so as to use more powerful currents. In this field there has been a legion of inventors. As a result of their labours we have a numerous array of what are called *transmitters*.

The main idea underlying the introduction of the transmitter is that transmission shall be effected, not by generating currents, but by producing large variations in a normally constant current which is supplied from some independent source, usually a battery. For this purpose the transmitter has two main features—one is the variable resistance, which is now almost always made of carbon in some shape or other. For instance, in the solid-back transmitter [4] it consists of a cylinder with non-conducting sides, and a bottom end of solid carbon, while the top of the cylinder is closed by a piston of carbon, the intervening space being filled up with fine granules of carbon. When such an arrangement forms part of an electrical circuit in such a way that the current must enter at one end of the cylinder and pass out of the other, the resistance offered to its passage may be varied through large limits. The resistance is greatest when the pressure of the piston on carbon granules is a minimum, and least when the piston is pressed firmly down on them, the difference being ascribed to the more or less intimacy of contact between the granules. The other feature common to all transmitters is a flexible diaphragm which can respond to the vibrations of the voice, and which, in this case, is rigidly connected to the piston, so that the latter is constrained to follow all its movements. This arrangement is depicted in 5

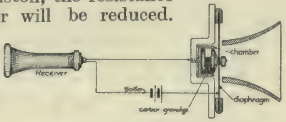


3. DISSECTED BELL RECEIVER

A. Shaped ebonite ear-piece which screws on to end of *D*, and supports *B* in front of *M*. *B*. Thin iron diaphragm which is held in front of *M* by *A*. *C*. Ebonite sheath which slips over *D*. *D*. Heavy brass case with internal screw to receive *K*. *E*. Screw for attaching *G* to top of *D*. *F* and *N*. Bolt and nut to clamp together *J*, *L*, and *K*. *G*. Ebonite terminal cap with strain hook. *H*. Heavy leading wires to connect outer terminals to thin coil wires. *J*. Permanent magnet, each limb $3\frac{1}{4}$ in. long. *K*. Z-shaped brass piece with screw to fit interior of brass case (*D*). *L*. Soft iron pole-pieces, each carrying a coil of wire. *M*. Two coils of silk-covered wire.

The introduction of transmitters enabled much more powerful effects to be obtained.

Referring to **5** we see that we now have a current flowing continuously through the transmitter and the receiver, so that when the terminals are properly connected the field due to this constant current will assist the field due to the permanent magnet and increase the tension on the receiver diaphragm. If, now, a sound wave impinge on the transmitter diaphragm so as to cause it to press down the piston, the resistance of the transmitter will be reduced. This will cause an increase in the strength of the current in the circuit and so increase the attraction on the receiver diaphragm, drawing it inwards. The *compression* sound wave which affected the transmitter will be followed by a wave of *rarefaction*, which will allow the transmitter diaphragm to swing out beyond its normal position. This has the effect of reducing the pressure on the carbon granules. Reduction of pressure lessens the intimacy of contact between the granules and so causes increase of resistance, and this in return causes decrease of current. At the receiver end the decrease in the strength of the current reduces the tractive force acting on the diaphragm, which is thus allowed to swing out, and so imitate the movements of the transmitter diaphragm.



5. RECEIVER AND TRANSMITTER

The Induction Coil. This combination is, however, only efficient when the transmitter forms a relatively large part of the circuit resistance. With increased length of external circuit there is reduced variation of current strength. To remedy this the induction coil, already in use for other purposes, was introduced into the telephone circuit by Edison. It consists of a core made of thin iron wires 3 in. to 4 in. in length laid lengthwise; surrounding this core there are two to four layers of fairly thick insulated copper wire. This, in turn, is surrounded by about ten or twelve layers of very thin insulated copper wire. The thick winding is called the *primary*; it may have about 400 turns. The thin winding is called the *secondary*, and has usually about 2,000 turns.

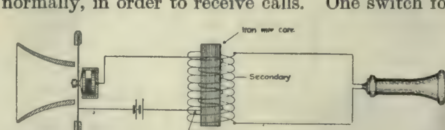
The action of an induction coil is very interesting. In the first place, it depends on Faraday's laws of electromagnetism, which have already been referred to in connection with Bell's telephone.

In **6** it will be seen that the transmitter and battery are connected to the primary of the induction coil, while the lines to the distant receiver form, with the secondary of the induction coil, a separate circuit.

As the primary is of thick wire its resistance is small, usually about 1 ohm, so that the current in the primary is considerable.

When the diaphragm vibrates, the variation of the current is very large, because the transmitter is the principal resistance in the primary circuit. Now, while this current is flowing the primary coil and the enclosed iron core form an electromagnet equivalent to the steel magnet in **1**, and the secondary winding is linked with the lines of force due to the primary in the same way as the coil shown in the first illustration. A decrease in the current flowing in the primary will reduce the number of lines of force linking with the secondary, and corresponds to the withdrawal of the steel magnet, while an increase of the current corresponds to thrusting the steel magnet into the coil. It follows, then, that increase of the microphone resistance will produce in the secondary a current in one direction, while decrease of the microphone resistance will produce a current in the opposite direction. This is an important gain, because, whereas, without the induction coil we had only a current variation from a positive minimum to a positive maximum, with the induction coil we have a variation from a positive maximum through zero to a negative maximum. Equally important is what may be called the "gearing" effect of the induction coil. In the primary circuit we have a comparatively large current at a low voltage. In the secondary, which is connected to the line, it is better to have the energy generated with higher E.M.F. suitable for transmission over long lines. The induction coil enables this modification to be made. For analogy, we may look at the chain gear of a bicycle. The energy supplied by the foot is transmitted by the chain to the driving wheel. Now, the amount of energy transmitted depends upon two things—first, the power applied to the crank, and secondly, its rate of rotation. These two may be varied in any way so long as their product remains constant. If the two wheels over which the chain runs were of the same diameter, it would be found that while only small power was required to attain a given speed the rate of rotation would be inconveniently high. If, now, the crank gear-wheel is made with a diameter double that of the other gear-wheel, the same speed will be attained by rotating the crank gear-wheel at half its previous rate, but the power exerted by the foot will now be double that in the first case. Similarly, in an induction coil, the energy transmitted from the primary to the secondary is the product of the current and the voltage at the terminals of the coil. The voltage varies in accordance with the number of turns. See also page 1657.

The Automatic Switch. With the exception of the new central energy system instruments [**5**] this is the invariable arrangement during actual speaking on all telephone circuits. The drain on the battery during speaking is very great, and a switch was arranged to disconnect the primary circuit after use. As batteries were necessary for the microphone circuit, they were also used for calling, each station being provided with trembler bells. It was also necessary to arrange a switch to connect the lines to the bell normally, in order to receive calls. One switch for



6. TRANSMITTER, INDUCTION COIL, AND RECEIVER

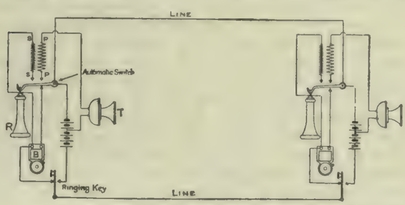
both these purposes soon became the universal arrangement; and to prevent mistakes it was used as a rest for the receiver, and so became automatic in its action, and is always referred to as the *automatic switch*. Figure **7** shows two stations arranged for battery ringing; a press button ringing key, P, is used to connect the calling battery to the line.

Magneto Stations. Battery ringing stations were found to be troublesome to keep in order, and, moreover, the battery power had to be

carefully calculated to meet each particular case. For long circuits, relays were introduced into the *main* circuit, displacing the bell, which was actuated by the relay closing a local circuit. This, of course, meant an addition to the number of points where trouble might occur. The most difficult case occurred when it was desired to place several stations on one line, and so much difficulty was experienced in connection with batteries and relays that a solution of the general problem was sought and found in the magneto generators and magneto bell. The generator, already described on page 5177 takes the place of the battery. It is usually wound so as to generate current at from 70 to 120 volts, and the gear-wheels are arranged so that the armature, when the handle is turned at average speed, makes about sixteen revolutions per second, or, say, 1,000 per minute. A switch is included in the generator, which normally short-circuits the armature resistance, but is opened immediately the handle is rotated.

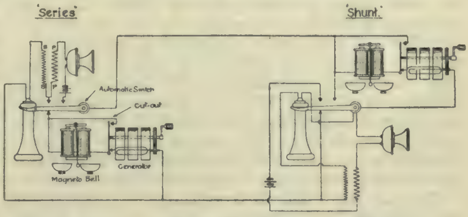
The magneto bell shown in **8** is an electromagnet with a rocking armature to which a rod and hammer are rigidly attached. The cores of the electromagnet and the armature are polarised by the large permanent magnet, so that both poles tend equally to attract the armature. When alternating currents are received this balance is upset, and a rocking motion, corresponding to the rapidity of the alternations, is produced. The most usual resistance is 1,000 ohms, and a good generator will ring such a bell through 20,000 to 60,000 ohms. Figure **8** exhibits the two most usual methods of connecting magneto station apparatus. The shunt method is gradually displacing the series system.

Exchanges. The first telephone exchange is said to have been opened in Boston, U.S.A., in 1877, but an exchange to which a number of subscribers provided with Wheatstone A B C telegraph instruments were connected had been opened at Newcastle-on-Tyne in 1864 by A. W. Heaviside, and at the time of the invention of the telephone had grown to 60 subscribers. As the use of the telephone increased, the obvious convenience of having a number of subscribers connected to one central point, with arrangements so that any one of them could rapidly and conveniently be put into communication with any other, led to the introduction of exchange systems simultaneously in numerous towns. These systems were usually provided by men whose experience had



7. BATTERY RINGING TELEPHONE CIRCUIT

been telegraphic, and so telegraph practice was followed; single wires with earth return were provided, and the indicators at the exchange were arranged so that they were directly in the line circuit and talking had to be done through them. Owing, however, to the excessive sensitiveness of the telephone, it was found that when speaking was carried on on one wire it was audible in telephones attached to parallel wires, this result being brought about by the mutual induction between the two wires, on the principle to which we have already referred in describing the action of the induction coil. The only cure for this serious trouble was the somewhat expensive one of making the line circuit metallic, thus doubling the cost for wire; and even when this had been done it was found that when the two wires of a telephone circuit were parallel to a telegraph circuit the latter caused inductive interference, unless the telephone wires were arranged so that they were throughout at equal distances from the disturbing line.



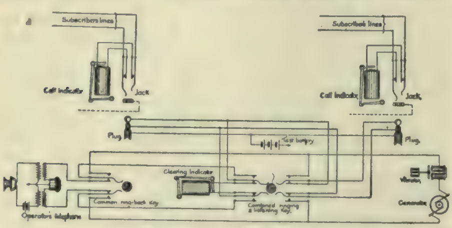
8. MAGNETO GENERATOR-RINGING TELEPHONE CIRCUIT
Showing "series" and "shunt" methods of connecting

The "Bridge" System. At the exchanges it was found that while the series arrangement of the indicators was quite suitable for receiving signals, it seriously interfered with the speaking efficiency; and Heaviside demonstrated that it was necessary to take all such apparatus out of the main circuit, and connect them in "bridge" from wire to wire, so that when two subscribers were in communication there should be a continuous metallic circuit, free from all apparatus, from the one subscriber's instrument to that of the other. At the exchange it was necessary to provide, first, an indicator by means of which a subscriber could call the operator; and, secondly, means to enable the operator to reply, which took the form of flexible cords, terminating in plugs suitable for fitting into the termination of the subscriber's line, which was called the *answering jack*. The cords and plugs were arranged in pairs, so that one plug might be connected to the calling subscriber and the other to the subscriber who was subsequently called. Bridged across the two connecting wires there was, firstly, a *listening key*, which enabled the operator to connect her own telephone to the plugs; and, secondly, a *calling key*, which enabled the operator to connect a generator to the *calling plug*, and send out calling currents to the required subscriber. The answering jack was arranged so that when the operator plugged into it, the subscriber's indicator was cut out of the circuit, and, therefore, each pair of plugs had bridged across them a high resistance *ring-off* indicator [**9**].

Operating a Call. Now we can describe an operating transaction. The subscriber calls by turning the handle of his generator, the calling indicator drops at the exchange, the operator replies by plugging into the answering jack, at the same time turning the listening key, which connects her to the pair of plugs. The subscriber gives the number he requires, the operator connects the calling plug to that number, and presses the calling key which connects the generator to the calling plug. When the subscriber answers, the operator hears them begin the conversation, and then goes out of circuit by restoring the listening key to its normal position. At the conclusion of the conversation

the subscribers were required to ring off by giving a turn to the handle of the generator. This actuated a ring-off indicator at the exchange, and the operator thereupon withdrew the plugs.

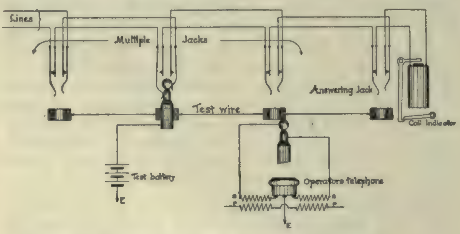
Difficulties Overcome. In these early magneto exchanges the indicators required a space of about 4 sq. in., and the answering jacks a space of 1 sq. in. each. The indicators were arranged in blocks of 50 or 100, and the answering jacks above or below them in corresponding blocks. In large towns, in spite of heavy rates, the convenience and rapidity of telephonic communication was such that the number of subscribers quickly increased, and this soon introduced new problems. One operator could deal with 100 subscribers, and two operators on adjoining switches could deal with 100 each, the cords being long enough to allow of interconnection between the two blocks. When a third switch was introduced, the question of connecting No. 1 block to No. 3 had to be considered, and this was arranged for by connecting a jack of No. 1 switch to a jack of No. 3 switch, and in this way extending the line as required from one operator to the other, the arrangements being made verbally. Clearly, this system could not be developed very far, and some other had to be evolved. It was desirable, as far as possible, that any one operator should be in a position to connect the subscribers she answered to any required subscriber, and this was arranged by duplicating the connecting points for each subscriber's line in such a way that there should be one connecting point within reach of every operator. As an operator can reach over the position to left or right of her, this meant one connecting point per three operators. The provision of this "multiple" system was a comparatively simple matter where only a few hundred subscribers were concerned, but when the number of subscribers mounted into thousands, great difficulty was experienced in bringing the size of the multiple down to suitable dimensions for the operators. It became clear that the extent of the operator's reach determined the limiting dimensions for the switches. Switch space became exceedingly valuable, and the size of every item of the equipment was rapidly reduced as far as possible. The multiple also involved the introduction of a new feature in the operating. It was necessary to provide means by which the operator could ascertain whether



9. CORD CIRCUIT—MAGNETO SYSTEM

or not the required subscriber was "engaged." Provision for this was made by carrying round the multiple jacks a third wire, which was in connection with the brass bush forming the entrance hole of the multiple jack. All the plugs in use in the exchange were also provided with a third conductor, forming a sleeve for the plug in such a way that when inserted in any jack this sleeve was in contact only with the third, or test wire of the multiple. One pole of a battery was in connection with *all* of these plug sleeves, the other pole being connected to earth. The operators were provided with receivers having double windings, the junction of the two windings being connected to earth [10].

The Engaged Test. Before inserting a plug into any subscriber's line, the operator applied the tip of the plug to the bush of the nearest jack. If the subscriber was "engaged," a click would be heard in her receiver due to the passage of a current from the test battery, viâ the sleeve of the distant



10. PRINCIPLE OF ENGAGED TEST

plug, along the test wire, through the tip of the operator's plug, and so through the operator's receiver to earth.

On receipt of each calling or clearing signal on the indicators, the operators had to restore the shutter of the indicators by hand, which necessitated their being within reach, and, therefore, beneath the multiple jacks. This limited the downward growth of the multiple. To remedy this, a so-called *self-restoring indicator* was introduced, which allowed of the indicators being placed above the multiple and beyond the reach of the operator, and to some extent increased the space available for jacks. For some time 2,000 was the capacity limit of a multiple, but by further decreasing the size of the jacks, by the introduction of flat switchboard cables, and by the removal of the indicators, this number was rapidly increased to 8,000 and 10,000, and now even 20,000 can be arranged.

The Call-wire System. Further efforts in the same direction were made in America and in Scotland by introducing a system devoid of indicating apparatus at the exchange. The *call-wire* system provided for each subscriber a pair of wires terminating on the exchange multiple; in addition, a calling circuit was carried to the instruments of a group of subscribers, the exchange end of which terminated on the operator's headgear set. When a connection was required, the subscriber depressed a special call key, which connected his instrument to the call wire, and enabled him to speak directly to the operator. He gave his own number and the required number. The operator connected them by a pair of plugs, the subscriber turned his generator and called his correspondent, and on completing his conversation again depressed the call key, and requested the operator to disconnect him. The call-wire system has been gradually abandoned, because it required the subscriber to do work which can be better performed automatically at the exchange. It should be stated, however, that the principle is very usefully employed in modern systems between disciplined operators. Failure to ring off was also common to the magneto systems, and the need for separate signals from each subscriber, instead of one which might be from either, was felt.

Continued

THE GREAT REFORM BILL.

The Ministry of William Pitt. Daniel O'Connell and the Catholic Emancipation Bill. The History of the Reform Bill

Group 15
HISTORY
40

Continued from page 5555

By JUSTIN McCARTHY

PITT did his best to keep together the coalition of the European Powers, but depression of trade and other circumstances combined to make the war unpopular after a time, and the King also became very unpopular. The war went on, and though England was still successful at sea, the appearance of Napoleon on the scene changed the fortunes of war by land and the English generals suffered many defeats.

The Catholic Emancipation Bill. In 1800 Pitt wished to bring in a measure for the emancipation of the Catholics, which would have much helped to conciliate Ireland, but the King would not consent to it. But Pitt was determined, and the King had to accept his resignation in 1801. His successor was Addington—a Minister as subservient as North had been, and less capable. The Peace of Amiens was concluded in 1802, but war again broke out in the May of the following year. The King had another attack of madness, but, like the attack of 1801, it did not last long. At last the country would have no more of Addington, and insisted on the return of Pitt to the head of the Government. Pitt wished to include Fox in the Ministry, but the latter had long been a Whig, and the King disliked him, and refused his consent. A Tory administration was at last formed which carried on the war with Napoleon. Pitt, who did not long survive the fatal news of Austerlitz, died in 1806, just after the news of the victory of Trafalgar, in which Nelson lost his life.

A Famous Ministry. The King was now compelled to accept Fox and Grenville, who became the leaders of the famous "Ministry of All the Talents." But Fox died in the same year as his great rival Pitt, and there was no one to fill the place of either. Fox was one of the greatest statesmen of his time, and a still greater orator. Grenville wished to bring in some measures of justice to the Catholics, but this was prevented by the King, who tried to induce the Administration to promise never to bring the Catholic question up again; as they refused they were dismissed, and another Government formed, of which the Duke of Portland was the nominal, and Mr. Spencer Percival the real, head. The elections again resulted in a triumph for the King. In 1809 Spencer Percival became Prime Minister, and the majority of the Government was so large that they were able to survive their many mistakes in American policy. The successes of Arthur Wellesley (afterwards Duke of Wellington) in Spain at this time helped to make the Government popular. The reign of George III. came to an end in 1811. After the death of the Princess Amelia he became hopelessly insane, and though he lingered for nine years—blind, deaf, and mad—he was unfit to rule again. His eldest son, the Prince of Wales, became Regent.

The Romance of a King. The Regent, afterwards George IV., was born in August, 1762, and was of a very different character from his father. When only twenty he fell in love with Mrs. Fitzherbert, a Catholic, and there is now no doubt that he was actually married to her. But the Royal Marriage Act made the marriage invalid by English law. Had it been valid George IV. could not have succeeded to the crown. When he came of age his father settled on him £50,000 a year; the revenues of the Duchy of Cornwall were £12,000 a year, and Parliament voted him £30,000, and the same sum to pay off his debts. Notwithstanding this he was soon deeply in debt again, and the King added £10,000 to his yearly income. In 1788 Charles James Fox tried to improve his position with regard to the Regency, but the King recovered, and George's hopes were disappointed. In 1795 Parliament promised to discharge his debts, which amounted to as much as £650,000, on his marriage with the Princess Caroline of Brunswick.

The Prince was compelled by his financial troubles to accept these terms, but the marriage was a very unhappy one. There was one child of the marriage, the Princess Charlotte, and soon after her birth the Princess of Wales went to Blackheath, where she lived in retirement, the Prince returning to his old life of dissipation.

The Trial of Queen Caroline. The unpopularity of the Regent had been steadily increasing for some time. The Queen's enemies and the King's friends now spread reports about her founded, among other things, on the fact that she had adopted a child. These scandals resulted in the "Delicate Investigation." Evidence was collected by every means and the result laid before the King; but Caroline, who defended herself strenuously, was acquitted in 1807. Canning and Brougham were on the side of the Princess, as well as public opinion in general. In 1814 she obtained leave to go on the Continent, and she lived for a time on the lake of Como, where her conduct was certainly uconventional. When George IV. came to the throne, on the death of his father in 1820, he offered the Princess £50,000 a year to renounce the title of Queen and live abroad. This she refused, and in reply made a triumphal entry into London, where she was received with enthusiasm by the populace. Then the King's Government brought in a Bill of Divorce. The Queen was defended by Henry Brougham, afterwards Lord Brougham, the famous advocate and parliamentary orator, whose defence of

the Queen was one of his greatest triumphs. So great was his success as her advocate that the Bill had to be abandoned by the Government even after it had passed through the Upper House. There was no evidence of the more serious charges against the Queen, and though her conduct was imprudent the King's abominable treatment of her would have excused many faults on her part. Public feeling was altogether on her side, and the King became even more unpopular than before. On July 19th, 1821, the Queen presented herself at Westminster Abbey on the day of the King's coronation, and was brutally repulsed by the King's orders. The unhappy Queen died in the same year.

Daniel O'Connell. As Prince of Wales George had been known as a Whig, and was the friend of Fox and Sheridan; yet, as soon as he became King he tried to govern the country in the same manner as his father. He was, in fact, as bad a king as his father and not so good a man. Like George III. he resisted Catholic emancipation as long as he could, but he had eventually to give way. The Duke of Wellington, his Prime Minister and a strong Tory, declared that to resist the measure would lead to civil war, and he declined to commit himself to a policy which would have such a result. The Catholic Emancipation Bill was, therefore, brought in by Sir Robert Peel, passed through both Houses, and received the Royal Assent on April 13th, 1829. One of the first Catholics to take his seat in the House was Daniel O'Connell, the famous Irish leader who had given up an immense practice at the Bar to conduct the agitation for Catholic emancipation and had, in 1823, formed the Catholic Association. He was elected member for Clare in 1828, but was refused admission to the House because he was a Catholic. O'Connell, who was one of the greatest orators of his day, now led the agitation for Repeal of the Union, and was also in thorough sympathy with the Reform movement in England.

The King died on January 26th, 1830. In his reign lived many great Englishmen—Byron, Shelley, Keats, Sir Thomas Lawrence, Flaxman, Sir Humphry Davy, Dugald Stewart, Pestalozzi, and others.

William IV's Reign. William IV., third son of George III., succeeded in 1830. He was born on August 21st, 1765. When a boy he entered the Navy and later on served in America and in the West Indies. In 1789 he was created Duke of Clarence, and in the following year took his seat in the House of Lords. In 1811 he was made Admiral of the Fleet, and in 1814 he conveyed Louis XVIII. to France. In 1818 he was married to the Princess Adelaide Louisa of Saxe-Coburg Meiningen.

Before William came to the throne he had been a Whig, and even after his accession he seemed to be in favour of reform; but events at home, combined with the fall of Charles X. in France, alarmed him.

The demand for reform was becoming very strong all over the country, and vast public meetings were held everywhere. In 1830 Lord Grey, one of the leaders of the Opposition, asked the Duke of Wellington, the Prime Minister, a question on the subject of reform, and the duke replied that he considered that the present system could not be improved or rendered more satisfactory to the country. The Tory Government were defeated on another question, on which they considered it better to resign. The King had to accept their resignation, and Lord Grey then formed a new administration with himself as Prime Minister, Brougham as Lord Chancellor, and Lord Palmerston as Secretary for Foreign Affairs; Lord John Russell, then a rising statesman, was in the Government, but not in the Cabinet.

The History of the Reform Bill. On March 1st, 1831, the Reform Bill was introduced by Lord John Russell. This great measure was the beginning of the reforms in our representative system which, with many later improvements, have given England its present electoral equality; it did away with the Rotten Boroughs, and other corruptions of former times, and was the first step towards making the representative system truly representative of the people. The Bill had, of course, the support of all Liberals, and was also supported by Daniel O'Connell, who went further than others by declaring his belief in manhood suffrage, vote by ballot, and triennial parliaments. After an animated debate the second reading was carried by a majority of one on March 21st. The Government, feeling that it would be impossible to carry the measure with such a majority, determined to appeal to the country. Parliament was dissolved on April 22nd, and the elections resulted in a decided victory for the Government.

The Second Reform Bill. When Lord John Russell introduced the Second Reform Bill it was carried this time by a larger majority, and went up to the Lords, where it was thrown out on October 8th by a majority of 41. The King refused to create new Peers for the purpose of swamping the Tories in the Lords, and Lord Grey's Government resigned. But the Duke of Wellington was unable to form a Ministry, and the country was in a state bordering on insurrection. On May 15th Lord Grey's Government returned to office, and the King was now willing, if necessary, to create new peers. At the request of the King the Duke of Wellington withdrew from the House of Lords with about 100 peers, and so allowed the Bill to pass on June 4th. This was the great event of William's reign.

In 1834 the King dismissed Lord Melbourne's Government, but had to recall him in the following year, as the Government of Sir Robert Peel proved hopelessly weak.

Other reforming measures of this reign, the abolition of Colonial slavery, the improvement of the Poor Laws, and the Municipal Reform Act, were all the results of that great wave of popular feeling which had so suddenly come up.

Continued

PROCESSES IN ART METAL-WORK

Goldsmithing and Silversmithing. Iron and Steel Work. Enamels and Enamelling. Sand Casting

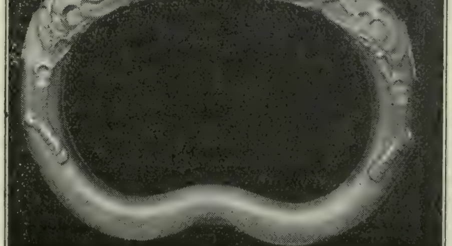
ART METAL continued from page 5529

By ALEXANDER FISHER

Goldsmith's Work. The jewel in the illustration [17] is built up of separate parts. First the vase shape is made by beating out a strip of metal the length of the circumference, and then the part immediately above it, first as a cone, the lower edge of which is spread out on a mandrel; then the base is beaten out of a small circular disc, in a saucer shape, and these pieces are soldered together. The granular surface is obtained by soldering grains of gold upon this. The simplest method of making these is to cut up minute pieces of gold wire of exactly the same length, and melt them on a charcoal block, pressing the pieces into the charcoal. Then after picking them out of the charcoal, they are shaken together in a bag, and afterwards rolled gently and evenly by hand between two true flat steel plates. By this means the grains will become spherical. A little calcined borax is mixed upon a slate, with water and gold solder filings added; a paste of this is made, and put on the gold. Now, with a mouth blowpipe, this is melted all over the surface. When this has been done, and it is quite cool, the grains are placed regularly upon the surface, and with a little gum tragacanth they are fixed. Then the flame of the blowpipe is blown gently upon them, drying the gum, and taking it up gradually to a red heat, so that the solder just melts, and causes the grains to adhere to the surface.

Many of the Etruscan jewels, such as that shown in **18**, were enriched in this manner. The making of the filigree is of the simplest description. Take a small wire, flatten it with a small hammer, and bend it round with round-nosed pliers. Then tie it in position with fine iron binding wire, and solder it to the main piece in the manner already described.

The armlet illustrated in **17** could be quickly and efficiently made by hammering the cylindrical shape in two halves from a piece of fine gold, of No. 10 metal gauge, by soldering them together, and then by cutting out the bird form in a thick piece of gold and soldering it with 20-carat gold solder. The head, horns, and paws are also made out of thick sheet metal and soldered to the body. Then the settings for the stones, which were in the body, are soldered on also. The probable way in which this was made was by modelling in wax in a cone, and casting, and afterwards chasing. This method is a good one, and is the best, as well as the simplest, but the cost of the solid gold would be very considerable.



17. GOLD ARMLET

Silversmithing. The cup shown in **24**, of which the author once made a replica, is one of the most highly admired objects in the South Kensington Muesum. It is of silver-gilt, and round the cup and cover it has pieces of green enamel *plique à jour*. It is not so much an elaborate work of art as a perfect piece of refined taste and craftsmanship. The principal excellence is the exquisite finish and proportion. The mode of its manufacture is as follows:

The body of the cup is hammered out of a sheet of silver, as described briefly in the general remarks under Hammering. A circular piece of sheet metal of No. 18 metal gauge, is cut out with shears. The width of the base is struck out with compasses, and then, upon a wooden block, the metal is beaten into a series of rings,the metal being held at an angle of about 30° to the block, and after annealing, the operation is repeated at a greater angle, and so on. Then it is turned over on to a stake and beaten from the outside, and thus drawn in. Finally, it is planished and polished. Now upon this is marked out the exact position of the mounts to hold the enamel. These mounts, made from a thick piece of wire, are chased and drawn by hammering, chiselling, and filing. Then the enamels are made as described under Plique à Jour. Now, cut out the spaces, and upon the body pounce with a sharp graver the pattern. After it has been gilt, the enamels are fixed. A more ornate sample of the same class of work is shown in **18**.

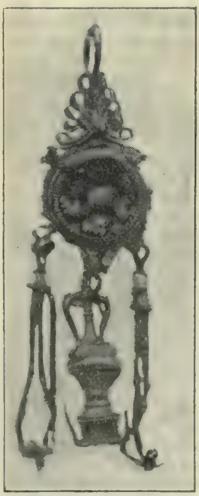
Wrought Iron and Steel. From the fashioning of armour plate, the forging of a damascened and jewelled Toledo blade, to the humble smithing of a horseshoe, from the making of an anchor to a grille or lock-plate, forms a fascinating study of work in iron and steel. Of late years, the smithing of iron has become one of the finest crafts. In ancient times, when all objects of utility, as well as of adornment, were marked with a desire for beauty, when the most frequently used kitchen meat-jack was regarded not only as a thing of use, but also as something that might be made beautiful, iron work flourished in all its excellence. Contrast the iron work of from 50 to 100 years ago, when it was deemed sufficient if it served its purpose and nothing more, with such work of ancient times—with the hinges illustrated in **21**. Why is it that a piece of engineering work is generally ugly? It

should be that the tool, or structure, which serves its purpose of utility best should also be the most beautiful, for beauty depends more upon the fitness of intention to purpose than upon anything else, and any extraneous adornment or unsuitability, or unnecessary feature, should signify a defect in design. And so it does. For, rightly considered, it is always the beginning, and therefore imperfect engineering or mechanical inventions which are ugly, and as they grow to perfection as things of utility they become less ugly.

Iron and steel are the most useful of all metals, but most of the ironwork, engineering or otherwise, which one sees is not beautiful, principally because it either fails in its purpose or does not completely fulfil it. The main characteristics which distinguish iron and steel from other metals are greater ductility, hardness, and infusibility. They oxidise more freely, and possess the property of becoming welded under pressure, produced generally by hammering when heated to a soft state. Steel, which is carbonised iron, differs from iron in that it is much harder and more brittle, but less malleable and ductile.

18. EARLY GERMAN CHRISMATORY

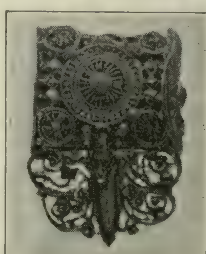
Varieties of Iron and Steel. There are substances lying intermediate between iron and steel; these are hard irons and soft steels, which depend upon the amount of carbon introduced into the iron. They are employed in a variety of ways. The most suitable iron for wrought purposes is almost pure iron, and contains but one-tenth per cent. of carbon. This will not harden under any circumstances, and welds readily. It is fibrous and tough. The greater the proportion of carbon in the composition of steel, the harder it is. It fuses at a lower temperature, it is granular, very tough, springy, and capable of being made soft, hard, or brittle. The very earliest forms of wrought iron show that the ore used was obtained from meteoric ore, as nickel is discovered in it when analysed, and there is a certainty that they were unable to smelt the ordinary ore. It was the custom, due to necessity, for the earliest workers in iron and steel to make all their own tools, and we know nothing which is better training than this. For to make a file, a pair of pliers, a repoussé tool, a mandrel and a graver, requires a great amount of knowledge and skill, and no doubt assisted the apprentice in obtaining a mastery over his material which, in most other ways, would be insufficiently acquired.



19. GREEK GOLD EARRING

In Theophilus' book we read of the method employed at that time in making steel and iron tools. The principal operation in wrought iron which distinguishes this work from all other kinds is that of welding. Welding consists in making two pieces of iron red hot, and consequently soft, and while in this condition, of hammering them together until they form one piece. It is the most complete union in all metalwork, for it is the absolute junction of two separate parts of the same material by itself; whereas, all other metals are joined by a solder of some kind. The most general methods of wrought-iron work are bending, chiselling, welding, riveting, and hammering.

Methods of Working Iron. Bending of thick iron is always done while the metal is red-hot, either upon a mandrel, in a vice, or upon an iron shape, and as it is heavy work, it is done by a man and his assistant. While one holds it securely with tongs or places it in a vice, the other beats it with a hammer, or twists it with other tongs. With leaf work, the iron is cut out from the sheet to a template, and is generally beaten into different shapes while cold, or if thick, while hot. Rods of all sizes, sheets of almost any thickness, strip of any gauge, can be readily procured from the metal merchant. In the forge, fine breeze is used, so that it falls closely round the iron. Small breeze burning is used with the bellows. It requires quick handling. In the making of any part, the best method of procedure is to make a pattern or template, on which the scroll or curve can be tested. In making thin work, it is scarcely necessary to heat at all, save for welding; but we deprecate very strongly the employment of thin iron out of doors, as in this climate it corrodes quickly. But a different set of tools and much greater skill is required



20. ANCIENT GREEK GOLD EARRING

21. MEDIÆVAL FRENCH CHEST HINGES

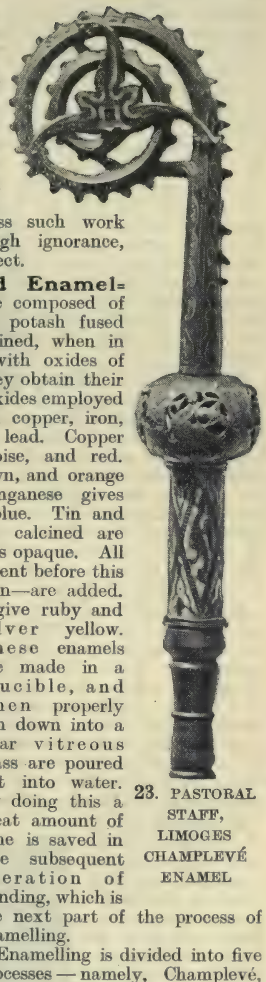
in dealing with thick iron. When using thick iron bar, the simplest way is to bend it by striking it over the anvil, or over shapes fixed in a vice. The anvil, owing to its tapering, circular, and flat ends, can be used for almost every variety of curve. The ease with which iron can be bent while red-hot is one of its sources of danger, inasmuch as it is apt to shrink, unless held firmly and beaten slowly. The geometrical volute in the scroll is never to be commended. It is one thing that the wrought-iron worker usually seeks to achieve, and it is a good thing to be able to do it easily, but only so that something better may be done in which the curve is one thought out and studied. As one walks along the street he notices that it is the most common form employed, and the result is dismal.

Cast Iron. The description of the method of casting in iron [22] will be given under Sand Casting. It is sufficient for our purpose to compare cast iron with wrought iron. Now, there is, so far as craftsmanship and treatment, no comparison in all such work as grilles, screens, and such places as require lightness in design. But where more massive work is required, such as newel posts to a gate, or large fire-dogs, or relief for the back of grate, then cast iron, suitably designed and handled, has its proper place. The work of Alfred Stevens in this material is, in some respect, the finest that has been done; but in spite of his great name, commend us to the work of some of the German and English cast-iron craftsmen of the early part of the fifteenth century. For iron suggests strength of a rude, simple kind; massive, blunt, heavy, solid, and full of power, not the polished, curving, adaptable, pliable, facile substance that copper or silver is. This remark applies largely to wrought iron as well as to the cast variety, for thin wrought-iron work is very unpleasant. I have frequently found wrought-iron railings with twisted scrolls and leaf work that you could

22. CAST-IRON GONDOLA PROW, VENETIAN

break off with your fingers. Imagine what they will look like in a few years, when no amount of paint will hold them together. Again, one frequently sees parts which should have been welded held together by solder. Architects who pass such work are culpable through ignorance, indifference, or neglect.

Enamels and Enamelling. Enamels are composed of silica, minium, and potash fused together and combined, when in a state of fusion, with oxides of metals by which they obtain their colour. The chief oxides employed are those of cobalt, copper, iron, manganese, tin, and lead. Copper gives green, turquoise, and red. From iron, red, brown, and orange are obtained; manganese gives purple and cobalt blue. Tin and lead combined and calcined are used to make enamels opaque. All enamels are transparent before this calx—of lead and tin—are added. Chlorides of gold give ruby and silver yellow. These enamels are made in a crucible, and when properly run down into a clear vitreous mass are poured out into water. By doing this a great amount of time is saved in the subsequent operation of grinding, which is the next part of the process of enamelling.



23. PASTORAL STAFF, LIMOGES CHAMPLEVÉ ENAMEL

Enamelling is divided into five processes — namely, Champlevé, Cloisonné, Bassetaille, Plique à Jour, and Limoges, or painted enamels.

Champlevé Enamelling. Champlevé enamelling, of which a specimen is illustrated in 23, consists of two separate processes of engraving or carving and then filling these spaces in with enamel, and firing. A plate of copper, silver, or gold is taken and put upon pitch or resin attached to a bowl or stick (as described under Engraving), and the pattern sunk with a flat scorper to about one-sixteenth of an inch in depth, leaving the dividing outline of the pattern raised. Then the enamel is pulverised with a pestle and mortar in water until it is a fine powder. Now it is washed so that all the milky part is entirely removed, after which it is put into

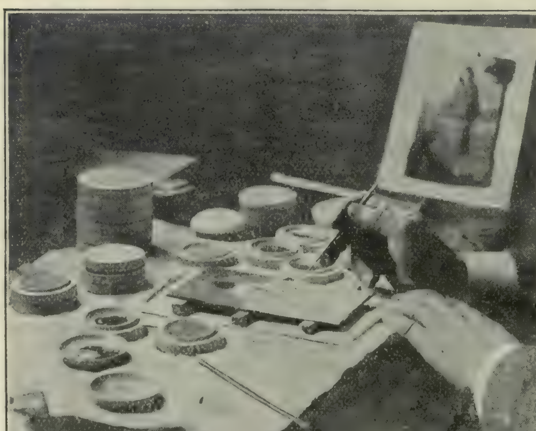
a saucer, and with the aid of a spatula or a brush the sunk parts are filled up with the granulated enamel. It is now dried at the furnace, and when the furnace is of a pale red heat, it is slowly and carefully introduced, supported on a fireclay or iron planche. When it has become shiny it is withdrawn and allowed to cool. This is then examined, and if any parts are below the surface of the raised metal lines they are filled up again as before and fired once more. It is once more removed from the furnace and upon examination it will be found to have some parts raised beyond the others; these are ground down with a corundum file and water, and then refired.

Cloisonné Enamelling. Cloisonné enamelling differs from the preceding only in the process of its preparation for the enamel. In this case the cloisons or flat, thin strips of metal, either gold, silver, or copper, are soldered to the metal surface to be enamelled. When the plate has been cleaned in "pickle" (sulphuric acid and water) the spaces are filled in as before and fired.

Bassetaille. This is a process in which the metal is carved in relief below the general surface of the surrounding metal. The metal is cut sharply with gravers and scorpers. It is most advisable first to make a careful model in wax, and then to copy it in the metal. Then fill in and fire. There are no metal divisions in this case, but by careful handling the edges will not mix, and they do not do so in the furnace unless greatly overheated.

24. BEAKER, WITH COVER, FIFTEENTH CENTURY

Plique à Jour. Plique à jour is identical with cloisonné enamelling save that there is no background of metal to which the wires or cloisons are soldered. They are simply soldered to each other and between these spaces the enamel powder, mixed with gum tragacanth, is placed, dried carefully, and fired on a support which touches the edge of those parts where there is no enamel. This, for simple work, is very effective and easy. For more elaborate work such as a bowl or a cup, the metal cloison is laid upon a metal or fireclay base, which are filled in and fired as described for champlevé, and the base is afterwards removed either by acid or other solvent.



25. ENAMELLING A PLATE ON WHICH THE SUBJECT HAS BEEN DRAWN IN IRIDIUM AND FIRED

Limoges or Painted Enamels. These enamels [26] are different in their manufacture from those obtained by the preceding processes. The sheet of metal is slightly domed so that it rests upon its edge. Underneath, it is covered with one coat of finely-ground enamel about one-eighth of an inch thick, and when this has been thoroughly dried it is turned over and the front is enamelled with a layer of rather coarsely ground enamels. The metal has, of course, been thoroughly cleaned as described under Pickling, before the enamel is spread upon it. This first layer is fixed and repaired, if necessary, until it is quite clean and bright. Then, upon this the subject or design is painted in white enamel, very finely ground with water, or with a glass muller upon a glass slab. With a brush it is then painted upon the prepared enamel plate [25]. A great degree of modulation can be given to this white by putting it on in varying thicknesses, and 27 is a good specimen of this. After firing, it is covered with transparent enamels and fired again.

Another most advantageous and peculiarly characteristic part of this process is the use of foil. Just as foil is used to heighten certain stones so it is used to heighten enamels. These paillons of foil are cut out and stuck upon the enamelled plate, after which the different coloured enamels are fused upon them. There is a great tendency to use foil, which should be guarded against as it is apt to give a meretricious effect.

The whole work is now taken in hand and parts are still further enriched with gold lines. The effect of a finely painted enamel is one of the most beautiful things it is possible to produce.

Sand Casting. Sand casting is generally employed where simple surfaces and planes are the dominating feature of the model. In preparing the model it is obviously necessary to bear in mind the process in which the work is to be carried out. For sand casting this should be arranged so that the mould in sand will draw easily in the fewest possible pieces. Sand casting is very largely the equivalent of plaster casting from a piece mould. In *cera perduta* the model may be of any shape, undercut, and of the most uneven and intricate

design. But the reverse holds good in sand casting. In modelling for small work such as jewellery, it is a great advantage to use rather a hard wax, which can be done with ease if it be warm, so that when it is cold it will set hard enough to press the mould from it. The larger the work the more desirable it is to have tools and appliances, but for jewellery the simplest mould in plaster and brickdust—or a sand mould—is sufficient.

26. ENAMELLED PLATE IN VICTORIA AND ALBERT MUSEUM

The sand, which is finely prepared, is put into a box and pressed down in a wet state, until it is almost a solid mass. Upon this the impression of the mould is made. Then the reverse of the model is taken in the corresponding half of the box. A V-shaped hollow is cut from the inlet of the box on to the impressed mould and then the sand is dried. Charcoal powder is now sifted all over and the melted metal is poured into the mould from the crucible. This, in the simplest possible terms, is how sand casting is performed. From this groundwork the most elaborate system of casting has been built up. The elaborations consist in making the pieces, or piece moulds necessitated by the different planes of the model. If these are numerous, as in a group of figures, it naturally involves a great amount of careful planning and execution. All such pieces are united with iron or bronze pins, as the case may be, and the core or heart of the mould is fixed in position also with pins, in order to keep the inner edge of the mould and the outer surface of the core in their exactly separated positions; then the metal in a liquid state may run between them. Any parts of the mould, such as arms or legs of animals, or figures which are extended, are usually cut away from the main trunk and cast separately. They are joined afterwards by brazing or soldering and riveting—a process which simplifies the casting considerably. Most of the work which is not large in dimension and is composed of many surfaces is now cast in the lost wax, or *cire perdu*, process. To compare these processes would be invidious, for so much depends upon the skill of the artisan. But the above is a guide to their differences and advantages.

27. PLAQUE OF COPPER PAINTED IN TRANSLUCENT ENAMEL COLOURS

General Considerations. It is hardly necessary to dwell further upon the various processes of metal-work or enamelling, or to elaborate in detail the intricate problems which present themselves in the practice of them. But it is as well to point out that the failures which everyone has to encounter at the beginning and during the pursuit of any art work, or, for that matter, any kind of work, and especially in its higher branches, wherein the element of chance so largely enters—such as in the case of repeatedly firing a piece of painted enamel—must all be considered as incidents by the way from which it is possible to derive valuable knowledge for future work. For the cause of each failure rightly accounted for and successfully overcome is a step on the ladder of achievement. Failures, then, should never be regarded in the light of discouragement and despair, but as obstacles in overcoming which increased knowledge and strength is gained.

It is most important also to bear in mind that the best results can be obtained only from a material by observing its properties and capabilities first, and never imposing conditions upon it which are foreign to its nature and composition, which will militate against success; but always endeavouring to express the true essentials of these properties. That is to say, the full appreciation of the fact that material (be it metal, enamel, or any other) which is taken up for the expression of an aesthetic emotion is in many respects both master and servant. By a rapid survey of work in which a misapplication of a material has been employed one can see what to avoid—such as in the case of mouldings, columns and capitals made in stone or wood have been copied in metal, or, again, where the forms of natural flowers and leaves have been closely imitated, and made as though they were growing out of a wire on the side of cup.

ART METAL *concluded ; followed by* PRECIOUS METALS AND JEWELLERY

continued from page 5548

ARCHITECTS' DETAIL DRAWINGS

A Description of the Detailed Drawings for the Parts of a House Supplied by Architects to Masons, Carpenters, Joiners and other Craftsmen

By Professor R. ELSEY SMITH

DETAIL drawings consist of drawings of portions only of a building prepared to a larger scale than the *general* drawings. The scales most generally used are those of ½ in., 1 in., 1½ in. or 3 in. to a foot. The actual scale selected for any particular drawing will depend on the size of the part to be represented and the degree of elaboration to be employed.

Some Suitable Scales. Drawings representing considerable portions of a building are very usually made to a scale of ½ in. to 1 ft. This scale allows such work as requires to be indicated on external elevations—brickwork, terra-cotta, stone-work, carpenter's work, tiling and slating—to be shown with sufficient clearness to indicate the method of putting the whole of the work together. Such a drawing may include work done by several different trades.

Where the design, method of construction, or framing is elaborate, or where there is much small detail in the mouldings, or enrichments, etc., as in the case of some joinery work, for example, scales of 1 in. or 1½ in. to 1 ft. are used. The latter is a convenient scale, being one-eighth full size, so that ⅛ in. equals 1 in.; but except for quite small objects it requires a very large drawing and is only necessary where there is much detail.

A scale of 3 in. to 1 ft. or one-quarter full size, is not often necessary, except for representing work in which there is a very considerable amount of detail, such as mosaic work and tiling. It is not satisfactory for indicating mouldings, which the architect should always represent full size.

Full-size Drawings. Full-size details may be combined in the same sheet with drawings to one of the other scales referred to. Thus, a plan, elevation and section of a door, with its frame or linings and architraves, may be given to a scale of 1 in. to 1 ft., and a section through the door panel and the architrave, if it is moulded, may be drawn full size.

The necessity for full-size drawings of mouldings and enrichments applies to all work in which such mouldings are made use of as a means of decoration, whether it be executed by the bricklayer, mason, carpenter, joiner, or plasterer. The effectiveness of a moulding depends on the careful proportion between the various parts; and if it is drawn one-fourth full size or smaller, reliance cannot be placed on its proper enlargement, and a small variation from the correct form may do much to destroy the effect that it is intended to produce.

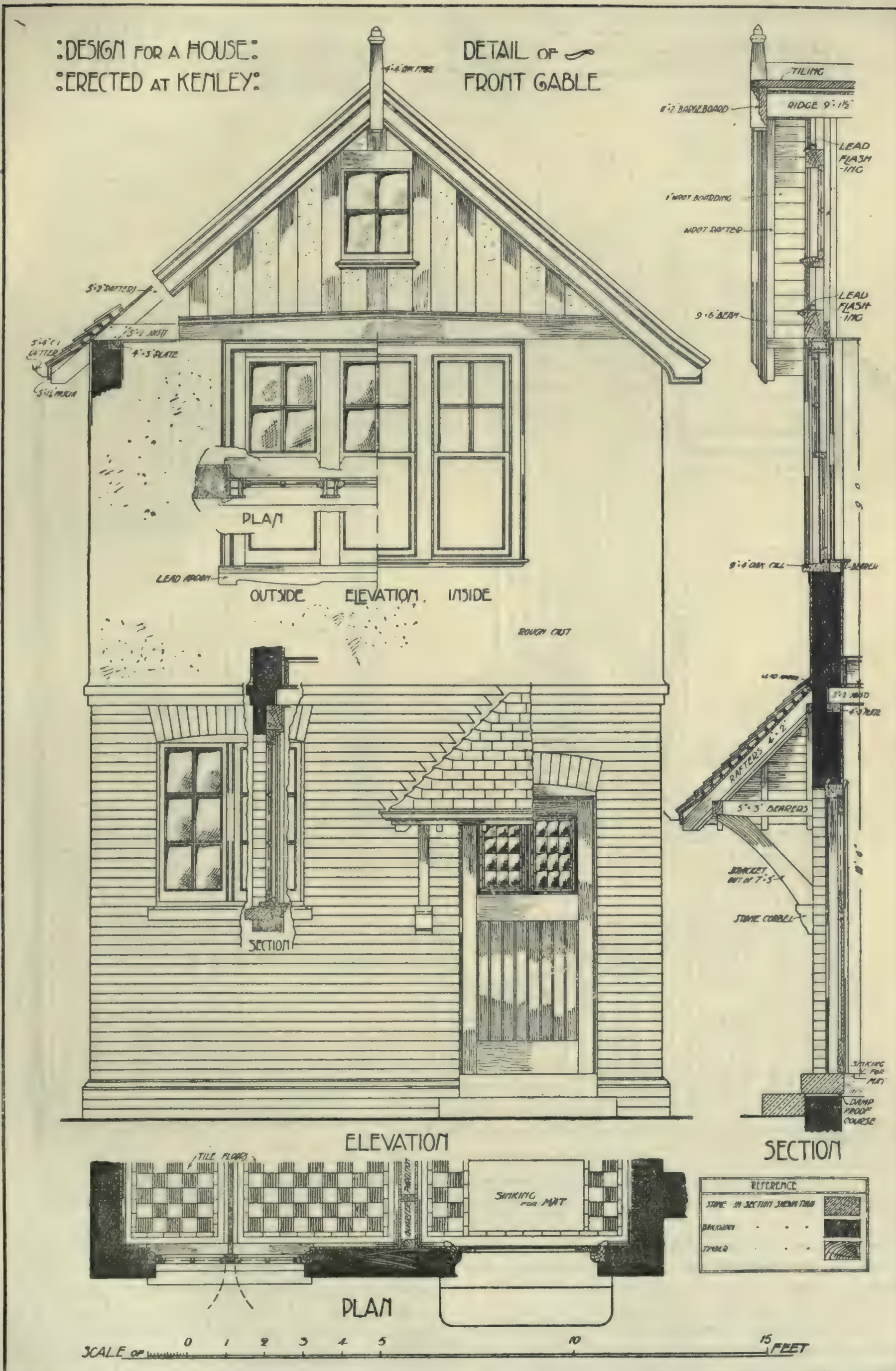
In the case of terra-cotta work, it does not suffice to draw the moulding full size, for the material is moulded in a plastic condition and is reduced considerably in bulk during drying and burning. The mouldings must therefore be drawn to the size required for the mould, which is larger than the finished size. The manufacturer will supply, on demand, a shrinkage scale prepared so that the work, if set out with it, will, when burnt, be of the size required. It is well always to use this scale and not merely draw the mouldings and enrichments to the finished size, or in the process of enlargement the delicacy and accuracy of the profiles and details may be lost.

Finishing Detail Drawings. Drawings made to a scale of ½ in. to 1 ft. are sometimes finished in ink, sometimes left from the pencil; but tracings from them for the use of the various workmen employed are made in ink. If the detail is to form one of the contract drawings it should be finished in ink; and this is desirable in any case if the work is elaborate, or deals with work of several different trades, so that a good deal of use is likely to be made of it. In the latter case it is also sometimes fully coloured to show different materials, both in elevation and in plan and section; but where a detail deals with one class of material only, and especially in the case of details to a larger scale than ½ in. to 1 ft., usually the sectional parts only are tinted.

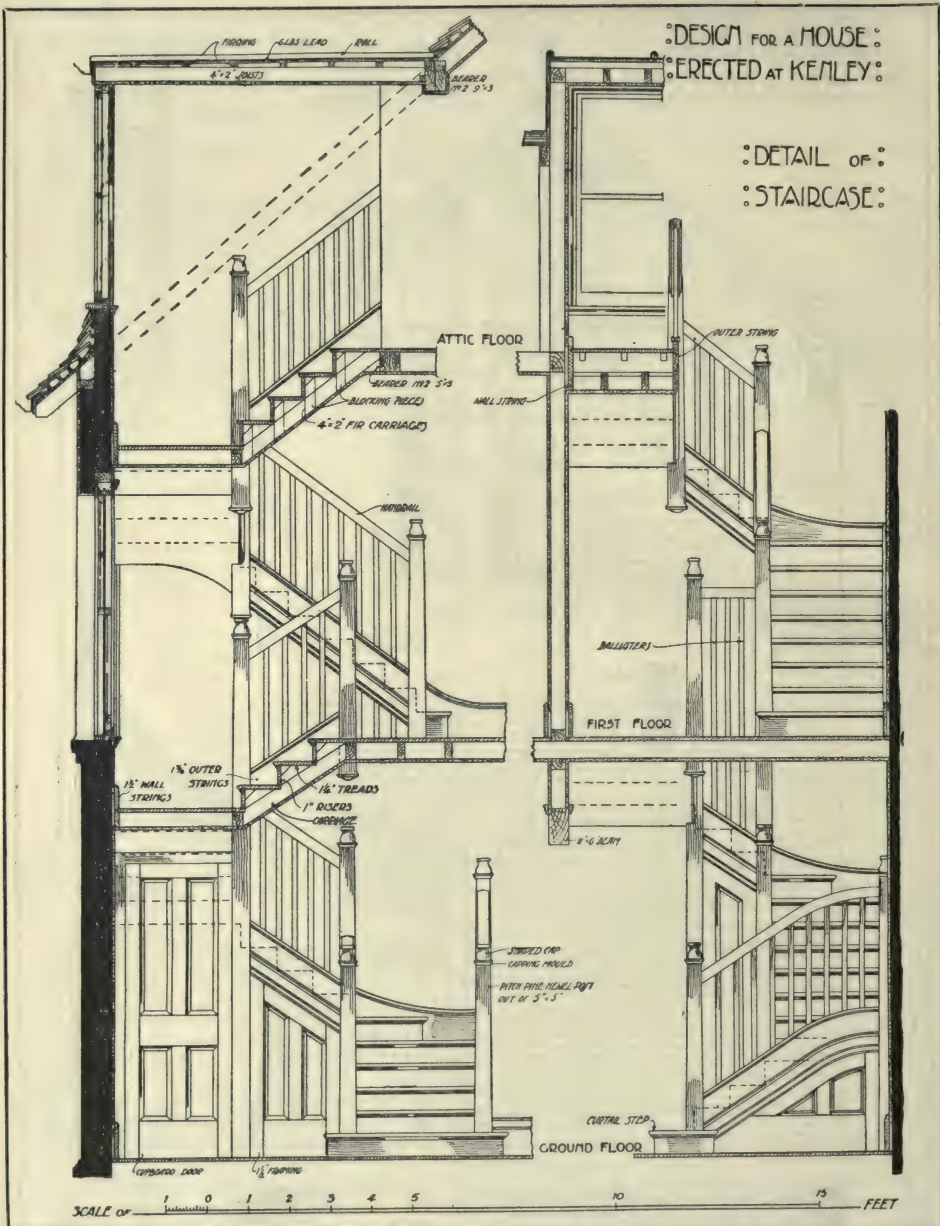
In the case of full-size drawings, the profile of mouldings or blocks of material is outlined with a line of colour and *not* filled in with a flat wash. In such cases the colour need not necessarily be the special colour described in a previous article, or the one usually employed to denote certain materials; for in such a case there can be no doubt about the material, and it is, on the other hand, sometimes convenient to draw plans of two courses one over the other (for example, the plan of a pier below the capital and the plan of the arch mouldings above), so as to show them in their proper relation to each other when they are not identical; in such cases different colours may be chosen to distinguish between two or more successive courses.

Variety in Architectural Detail. It is not possible to give a series of details of various constructional forms that would cover, to a considerable extent, the whole field of building construction, because the forms of many objects are influenced, not only by constructional necessity, but also very largely by their artistic treatment.

For example, in the case of two doorways, the width and height of both may be identical; while in many other respects they may differ materially in appearance and treatment, according to the style of architecture and materials employed. Any drawing, therefore, representing an architectural feature can only be considered, at least so far as the artistic treatment is



15. DETAIL OF FRONT GABLE

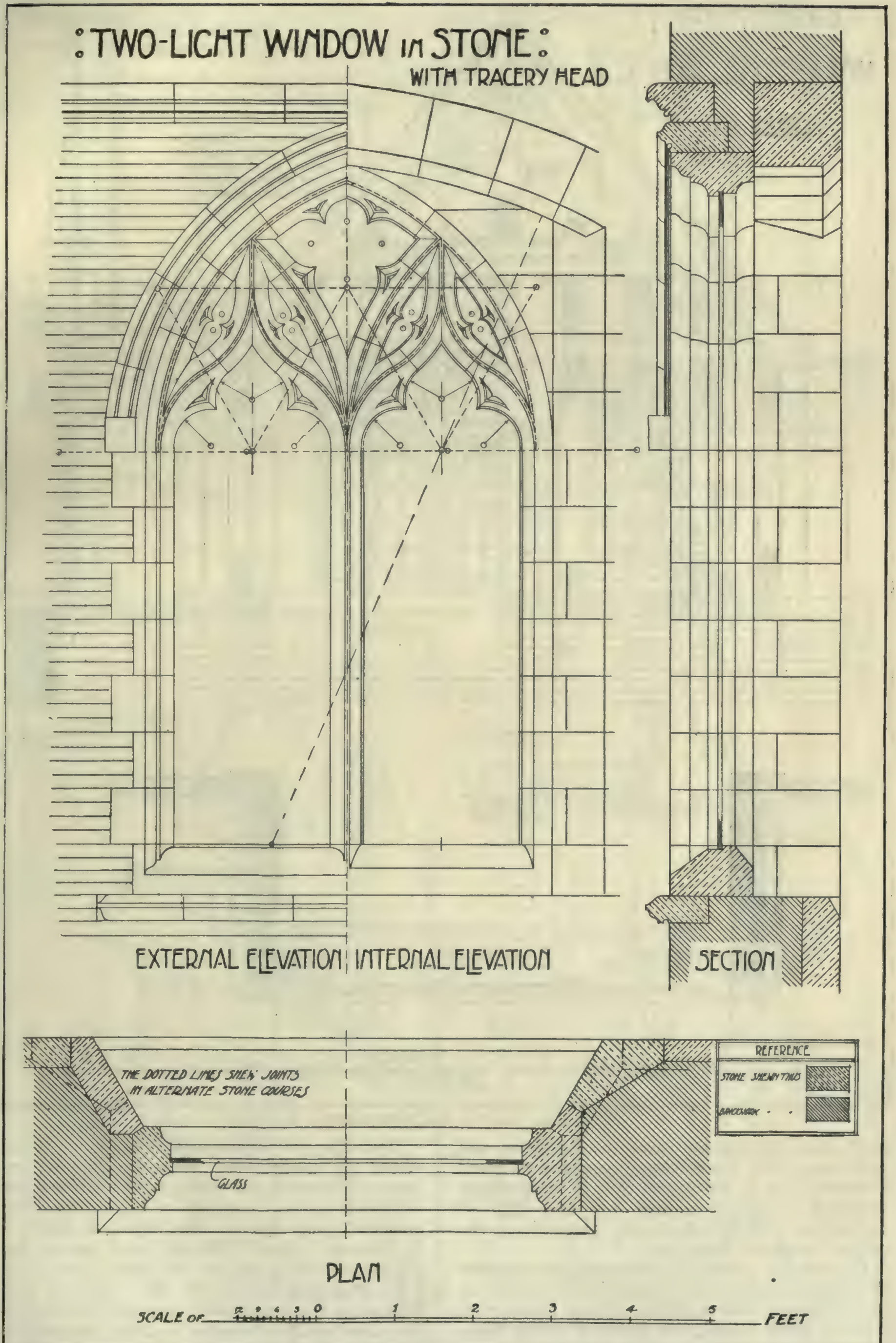


16. DETAIL OF STAIRCASE

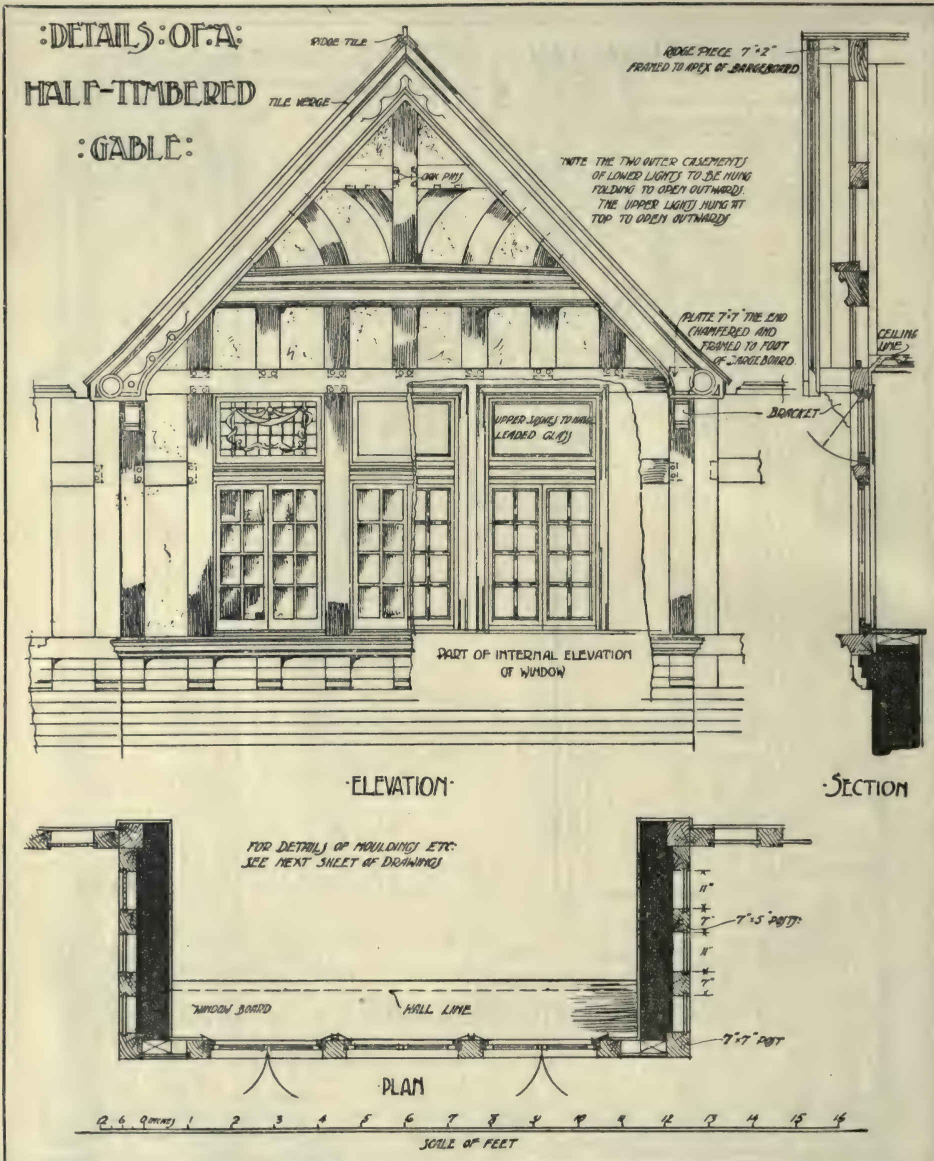
concerned, as one method of treating it, while it might be represented without altering the essential features of its construction in many different but equally satisfactory ways.

The drawings, therefore, that illustrate this article are not presented as the only correct and satisfactory method of treating certain features, but as examples of the manner in which certain fairly typical examples of work are represented, so that the foreman and workmen who have to actually create the work shall be able to comprehend thoroughly the architect's intention.

Joinery. A drawing such as **17** or **18** is sent to the builder and by him handed over to the foreman of the trade in whose shops it is to be executed, and he prepares from it full-size drawings on a board termed a *rod*. The joiner sets out vertical and horizontal sections, including



17. TWO-LIGHT WINDOW IN STONE



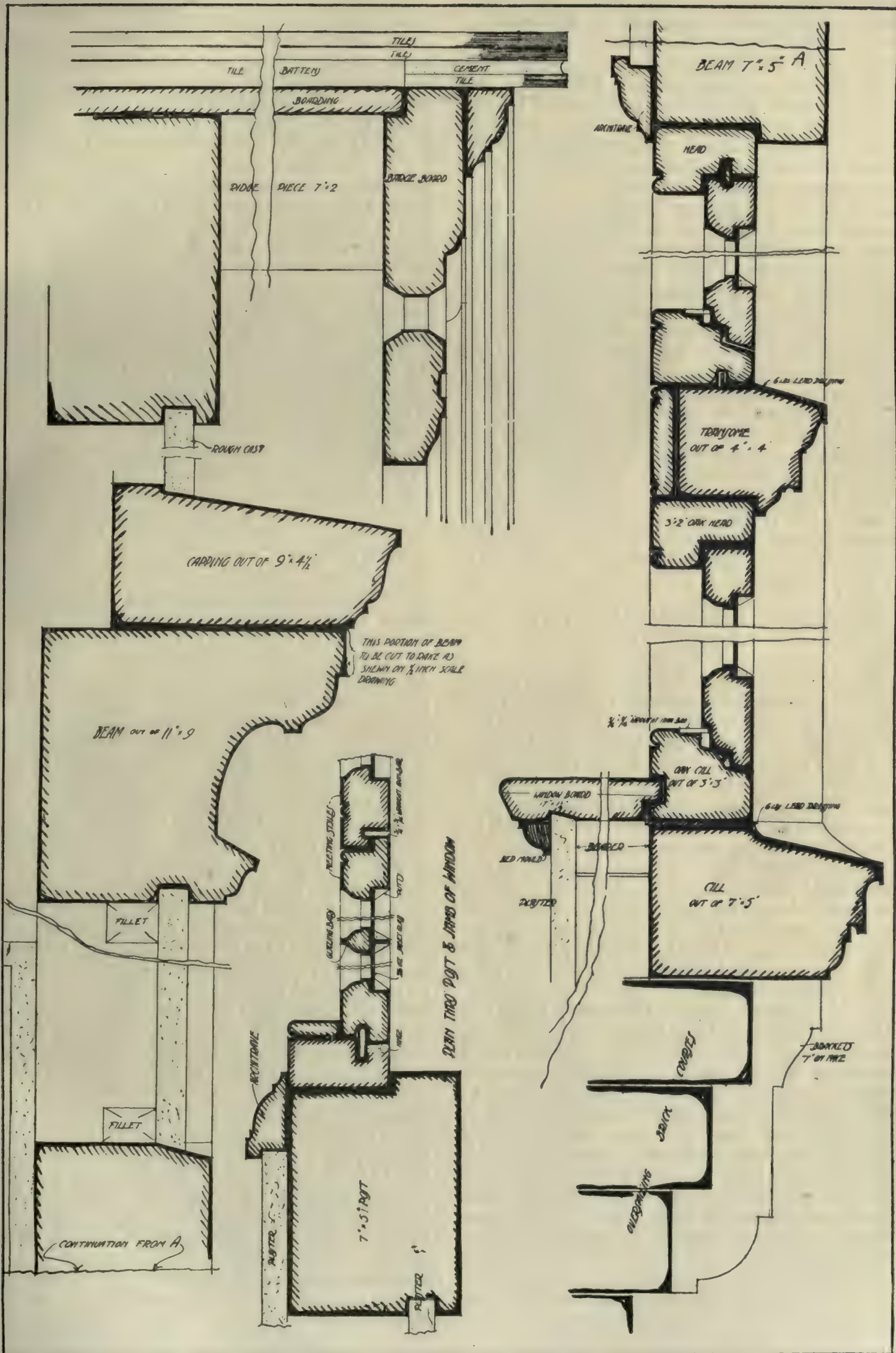
18. DETAILS OF A HALF-TIMBERED GABLE

mouldings, but not, as a rule, an elevation, and from these rods the necessary amount of wood is ordered, cut to scantlings, and in many shops prepared to some extent by the help of machinery, and then sent, with the rod, to the joiner's bench for finishing.

The rod for a small piece of work may consist of a single board, which is planed and the surface whitened, and the drawing is then made with a fairly black pencil, all sectional parts being hatched. Where the rod is necessarily large several boards are joined together.

Details of Masonry. The mason must, where any complicated forms are used, set out his work on the rod in elevation as well as in plan and section; and templets and face moulds are prepared from this in sheet zinc, as described in Masonry [pages 3039–40], and sent to the banker with the stone for the mason to work up.

In preparing his details the architect must determine in his own mind, and must show upon the drawings, the manner in which the work is to be framed and jointed, and the exact manner in which any enrichment is to be applied to it.



19. ENLARGED DETAIL SECTIONS OF A HALF-TIMBERED GABLE

This necessitates a thorough knowledge of the methods of work employed in the various trades or crafts and of the nature and limitations of the materials used in them.

In the case of the masonry detail [17], the general size of the window is regulated by the portion of the building it is to light, and this cannot in many cases be greatly varied; but the actual form of the window opening is susceptible of variation, and is determined *generally* by the style of architecture employed, and *exactly* by the taste or fancy of the architect, and this must be fixed with due regard to construction. In 17, which is small and not very complicated, so that it may be reproduced to a large scale, the head or upper part of the window is occupied by tracery enriched with cusps, and all the bars of such tracery, whether straight or curved, are usually designed symmetrically on a centre line; this is frequently the centre of a fillet formed in the stone, and in that case does not appear as an actual line on the finished work; but it is essential, to facilitate setting out, that it should be shown on the drawing, and in practice this is often done by a red or blue line for such centre lines, but in 17 by a dotted line. When curved lines are used the position of the centre from which they are struck should be indicated, and the length of the radius may be usefully figured.

Templets and Moulds. In the case of the stones forming the jambs, which only differ from each other in the area of their beds and perhaps also in the height of the stones, a templet giving the moulding should be prepared; and this may be made to show by its actual length the widest bed to be used, and, by a notch, the narrowest. In the case of the tracery, face moulds will be required for each block that differs in shape from any other, and bed moulds will also be required, which, in most cases, are formed by the templet giving the moulding of the rib.

All mouldings must be drawn full size, as the individual mason cannot be relied on to know the exact class of moulding suited to a particular style of opening; any moulded stops or carved enrichments must also be detailed, or, in the case of carved enrichments, full-size models may be prepared.

Carpenters' and Joiners' Details. Details of carpenters' and joiners' work are shown on the same drawings, for in a great many instances the carpenter is required to prepare work to which joiners' work is to be fitted, so that the two are intimately related [18]. Both in carpentry and joinery details the method of framing together the various timbers or boards of which any piece of framing is built up must be shown. In the case of carpentry, in which the joints are generally large, and in the main simple, it is not usually necessary to show full-size details of the joints, but the method of forming them should be clearly shown on the ½ in. or 1 in. scale drawings, and notes as to the actual scantlings of timbers may be added. If the piece of framing is to be ornamental in character, as, for example, an open timber roof, full-size details of all mouldings and enrichments should be supplied.

Details of joinery are usually made to a larger scale than those for the carpenter, mainly for the reason that the work is, as a rule, more intricate, but partly because the various objects made by the joiner are in most cases smaller in actual size and can be drawn to a large scale without the drawing being cumbersome. The mortises and tenons of any framing may be quite well shown to a scale of 1 in. or even ½ in.; but it is very usual in any complicated piece of work to show the method of framing together the various members on full-size details, and this sometimes requires considerable skill and ingenuity. As with other trades, all mouldings must be shown full size.

The Object of Detail Drawings. As already pointed out, the small scale general drawings serve a double purpose; their first use is to enable the architect to present to the owner an exact representation of what he is proposing to build, and they later serve as instructions to the builder for the erection of the work.

In the case of detail drawings, it very rarely happens that they are shown to the employer; this would only occur in the case of some very special piece of ornamental work—such, for example, as the fittings for a library or fireplaces and overmantels or similar work. They are, in the main, instructions from the architect to the craftsman, by which he is enabled to realise in actual work the architect's intentions, and all such drawings should be, therefore, as practical as possible, and do not require to be highly finished.

No useless labour should be expended upon them; any features that exactly repeat, for example, need only be drawn once, or, as in the window illustrated [18], the whole internal and external elevation need not be shown, but, where symmetrical, one half may be drawn showing the external and one half the internal elevation. A plan or a portion of a section may also be drawn where it will usefully elucidate construction, as illustrated [15], without reference to its effect on the appearance of the drawing merely as a drawing; notes as to sizes, differences of material and points in arrangement and construction may be freely added, the architect's object being to give to the craftsman such complete and clear instructions as shall prevent any chance of error.

Staircases. A staircase detail [16] is essentially a joinery detail, though it shows some amount of carpenters' work also. The student is referred for the plan to the illustrations previously given; the two sections here completely illustrate the construction and make it clear that at no point will any person using the staircase fail to have proper headroom. This drawing would give the joiner complete information as to the construction, but he would require full-size sections of the following details, which the size of the illustration makes it impossible to show and which are liable to variation according to individual taste: Nosing of tread, mouldings to outer string, skirting moulding, moulding of handrail, and detail of cap to newel.

DRAWING *concluded; followed by* DESIGN

MIND AND BODY

Natural Remedies of Ill-health : " Forces, Elements, Environments, Exercises." Ignorance and Ill-health. Heredity and Temperament. Temperament and Health

Continued from page 5541

By Dr. A. T. SCHOFIELD

THE natural remedies for ill-health include not only a very large class of *forces*, such as light, heat and electricity, but *elements*, such as air, earth and water ; also *environments* of all sorts, and *exercises*, active and passive, of every description.

Just as the general use of drugs is declining, so is the use and number of these remedies extending in a most marked way. Electricity alone has an enormous range of variety. Water, again, in spas and baths and beverages and hydropathic treatments, has endless ways of application. Exercise, in the form of massage, vibration, resisted exercises, climbing, calisthenics, etc., has a wide range of therapeutic efficiency, and so one might go through the list. Their increased use is due to two causes: (1) the fact that diseases are no longer regarded as distinct entities, which can be removed by special drugging ; and (2) to the discovery of the great therapeutic value of many forces unknown before, such as light, heat, vibration, and so on.

Natural remedies are spoken of further in dealing with the various diseases in which they are of value.

The Medicine of the Mind. Psychic remedies are a large and, at present, but an imperfectly understood class of remedies, the knowledge and use of which is increasing every day. They are of value in varying degrees in *every disease*, for there is no form of ill-health known that cannot be benefited by the mind, conscious and unconscious, both of doctor and patient. Every remedy yet named has a psychic as well as a physical value. Drugs, for instance, *act through the mind* as well as through the body ; and, indeed, there are many recorded instances where the mind has actually reversed the physical action, as when opium pills, which are constipating, given for sleep, have been thought to be aperient pills, and acted accordingly.

The power of every drug is increased or lessened by the mind. So with every form of natural remedy. Travel, spas, baths, electricity, massage, all have a marked psychic value ; and this value can be immensely increased in various ways. Suggestions made consciously or unconsciously by the patient or doctor or friends, or by all, can make an inert medicine powerful for good. This is the rationale of *placebos*, or inert medicines, designed to act solely through the mind and thus made of marked benefit. The late Sir William Gull well knew the worth of these.

But, besides acting through other means and treatments, psychic medicine can be made to act directly on the sick. Faith healing in all its forms, which works such undoubted wonders, is a proof of this. Auto-suggestion, the use of will power, and suggestions made by the doctor with or without the hypnotic state, are all illustrations of this.

The Need for Natural Remedies. No doubt psychic remedies are the most widely available, though by no means practically the most powerful. Theoretically, almost anything can be done with the body through the mind ; but the practical application has been so grossly abused and exaggerated that it is well to point out that the mind cannot always be thus powerfully influenced, and that, after all, drugs and natural remedies are easier of use, and in practice often far more powerful.

Finally, both wisdom and experience are much needed rightly to use these three classes of remedies, so as to do good and not harm, and cure in the shortest time the disease in question.

Let none think, in this nervous and fanciful age, that a perusal of these pages will produce the ill-health of which they speak. It is our duty to know our weak points as much as our strong ones, and, indeed, it can be easily shown that the knowledge of the former is the more valuable of the two. But it is ridiculous to suppose that in any well-balanced mind the thought of weak points makes one weak. The foolish and contemptible attitude is with one's head in the sand, to refuse to look at any weakness or danger.

What should we think of a governor of a besieged town who refused to walk round his walls to discover the weak parts, in order that they might be better defended, for fear of the survey making the town weaker ? We know well that such a survey is the surest way to make the town stronger, and prevent its capture. In the same way here, we not only consider carefully how and when the enemy may obtain an entrance into our city—the body—but also how he may be most successfully resisted and most easily expelled. The whole object of this section is to remove from our eyes that veil of ignorance that renders us in emergencies helpless and paralysed for want of that simple knowledge that we shall here try to give.

The Power that Knowledge Brings. These pages are written in the firm conviction that it will be impossible for their contents to be mastered without saving scores of lives from needless sickness, and many from preventable deaths.

And not only so ; this section especially should do more, and enable its readers, should ill-health have already effected an inroad through any ignorance or neglect, to understand how to resist and overcome it. No doubt prevention is better than cure, and it is also true that in many cases

the professional army of medical men must be called in to overcome the enemy. It is in the beginning of evils, and in the lesser dangers that so continually beset us, that the city can be so well defended by the citizens, and where the ordinary man, by a little knowledge, can check the disease from going further, and save a prolonged illness.

No idea is entertained here of trying to make a man a doctor, or of interfering in deep medical matters. The knowledge that these pages gives is that which every man should possess, and without which he cannot be said to be fully equipped for the battle of life.

Ill-health Not Always Due to Disease. Many will wonder why this section is termed ILL-HEALTH, instead of the more familiar word "disease" being used. The answer is that there is much ill-health which is not due to disease, the former being a much more comprehensive word than the latter, and here more useful. Not only so, but a man is concerned with his health, and ill-health is rather his subject, while disease is more properly the doctor's.

Disease is, however, as we have seen, an expressive word, for all disease causes disease, or want of ease, and so does all ill-health. Ease is characteristic of health, healthy fatigue and rest alternately with work, each morning being a resurrection and each week begun with the same health, spirits, and weight as the last. There is no loss of health capital, and the income or amount of daily force is not therefore diminished.

Ill-health is the opposite of all this, and, as a rule, the person is conscious of it. We say "as a rule" because there are some cases where a person may be much out of health and not know it, but there are more when he thinks he is out of health, and is not; for at such a time his mind, at any rate, is out of health, and that is a most important part of the man.

Ill-health may be the result of *functional* or *organic* derangement. In other words, it may be due to faults in the working of some organ, or to faults in its structure.

The Equilibrium of the Body. We are all familiar with the phenomena of a "rocking stone": where one stone of many tons' weight is so nicely balanced on another in a state of dynamic equilibrium that the slightest touch sets it rocking, a severe push from several men being required to displace the pivot so that it can no longer rock. This stone at rest may illustrate health; when rocking, *functional ill-health;* when displaced, *organic ill-health.*

Ill-health is really the result of two factors —the power of resistance and the force of attack. The first factor, *resistance to disease,* depends upon the condition of the individual, which makes him more or less vulnerable to attack; the second factor, the *force of attack,* depends upon the character of the assailant.

The causes of ill-health are therefore of two descriptions—*predisposing* or passive, connected with resistance, and *exciting* or active, connected with attack—and it is upon the varied combinations of these two that the special variety of disease or ill-health depends.

Let us illustrate this. You are standing at the back of a hot hall in company with others, in a strong draught. When the lecture is over you all go home. The next morning you have bronchitis, another rheumatism, another a cold in the head, another pneumonia, another a liver attack, while another is perfectly well. Here then is the same attacking or exciting cause—the draught of air (laden, of course, with germs)—and six different results, depending mainly upon the difference of the predisposing cause or the power of resistance.

The Causes of Ill-health. The chief predisposing causes are five: *sex, age, heredity, environment,* and *previous disease.* The chief exciting causes are the breaking of the five laws of health concerning *food, air, cleanliness, clothing, exercise, and rest.* We will look at them briefly in order that we may understand a little better in what ways our health is really threatened, and how these dangers may be avoided. We will take the predisposing causes in order.

Sex is a marked factor in determining a disease. There are, of course, special diseases of women and of men. But apart from this all a woman's organs are more finely constructed; her frame has less strength and less power of resistance, and the general ratio between women and men is as 5 is to 8. The climacteric periods at 15 and 45 are more serious with women. About puberty, girls especially are liable to nervous disturbances, also of the stomach, neuralgia, constipation, acute rheumatism, and anæmia. Women generally are more prone to diseases of sedentary and confined lives, especially consumption. Child-bearing also introduces, as a predisposing cause special to the female sex, a factor leading to much ill-health. On the other hand, men are especially liable to accidents, and all ill-health due to exposure; they are also liable to epilepsy, tetanus, gout, diabetes, spinal diseases, bladder, lung, and kidney diseases, and digestive troubles between the ages of 20 and 45.

The next predisposing cause of ill-health is Age. The seven ages of man are these:

(1) Infancy, from birth to 7–10th month.
(2) Childhood, from 1st to 2nd dentition.
(3) Boyhood, from 2nd dentition to puberty.
(4) Youth, from puberty to 20–25 years.
(5) Early manhood, from 25 to 45 years.
(6) Later manhood, from 45 to 60 years.
(7) Old age, from 60th year onwards.

The Chinese Ten Periods of Life. The Chinese divide life into 10 periods, and the divisions are so quaint that we give them here:

From 1 to 10—The opening degree.
From 10 to 20—Youth's experience.
From 20 to 30—The strength of manhood
From 30 to 40—Officially apt.
From 40 to 50—Error knowing.
From 50 to 60—Cycle closing.
From 60 to 70—Rare bird of age.
From 70 to 80—Rusty visaged.
From 80 to 90—Delayed opportunity.
From 90 to 100—Age's extremity.

It must be remembered that the reckoning of age by years is nearly always fallacious;

many a man is old at 30 and young at 60. Indications of old age, such as loss of hair and teeth, are also frequently met with in youth. But speaking generally distinctions due to age hold good.

The young suffer from infectious diseases, acute affections of the mucus membrane and glands, the skin and lungs, and especially consumption—from which diseases the old are mostly free.

They, on the other hand, are prone to all diseases due to degeneration and to decay—to diseases of blood-vessels, to cancer, chronic bronchitis, heart failure, and most chronic complaints.

Heredity and Health. It must be noted that we *do not inherit diseases, but weakness of certain organs that predispose to them.* The former leads to apathy and despair, the latter to action and hope. All of us are compounds in varying proportions of our six immediate ancestors, —*viz.*, our four grandparents and our two parents ; and practically any hereditary weakness we may possess must have been derived from one of these. Heredity, however, does not lead to fatalism. You study it, not to discover if you are descended from a drunken or a nervous stock, in order that you may be a drunkard or a nervous sufferer, but in order that, forewarned and forearmed, you may successfully resist these tendencies, and thus guard the weak points. We can all make ourselves healthier than we were born, for none are descended from six *perfectly* healthy ancestors ; and we can all avoid ever suffering from any particular form of disease to which we may have inherited a tendency. The writer firmly believes that every predisposing cause of disease can be overcome.

Temperament and Ill-health. But perhaps the way in which heredity is most marked is in what is called the constitution or *temperament.* This word means the sum total of our powers of resistance to ill-health, together with any marked predominance of any one system of the body over others, or special peculiarities that may stamp the individual.

We will, therefore, review the different types of temperament and constitution. These are generally divided into four—the *sanguine,* the *lymphatic,* or phlegmatic, the *bilious,* and the *nervous.* These varieties do not imply any disease, but are, rather, different types of health, the term " health " being always relative to the person, no two people having exactly the same standard of what constitutes health, and few approaching the abstract ideal we have indicated above. Certain characteristics are sufficiently predominant in each of these temperaments to distinguish them by ; though it must not be forgotten that while in real life we often find the typical specimens we here describe, we also meet with every variety and combination.

The Sanguine Temperament. The sanguine temperament is characterised by a florid complexion, full and rounded body, blue or grey eyes, and light-brown, auburn, or red hair. The circulation is full and active, the digestion good, the character hopeful, energetic, and self-confident, full of force in body and mind, as befits those who have a strong current of good blood. These people have large chests, small heads, small veins, good muscles, while their actions are energetic and decided. With regard to exposure to injury they are readily affected by sudden changes and contagious diseases ; and when attacked, the disease seems to lay a firm hold on them. They are more liable to acute than chronic diseases. They have, therefore, somewhat defective powers of resistance. The moral disposition seems also to yield to adverse circumstances, and the character not to be very stable. The temper is often hasty, though never sulky and unforgiving. They are volatile in disposition, fond of change of work and amusement.

In women this temperament shows its best qualities ; they are loving, devoted, and cheerful in mind, while in body the outline is rounded, the skin clear and often very fair. We thus get typical forms of female beauty among this type. This temperament is common among the Anglo-Saxon race.

The Phlegmatic Temperament. The lymphatic, or phlegmatic, temperament is marked by flaxen or sandy hair, light eyelashes, grey or light-blue eyes ; complexion fair, dull or muddy ; skin delicate and readily freckled. The body is heavy, often ungainly and ill-proportioned, with large joints and hands and feet. The muscles are large, but the movements are awkward and slow, owing to want of nervous vigour. The chest and head are comparatively small. The movements are slow, the passions evanescent, and soon subside ; the intellect is dull. The circulation being sluggish, the nervous centres are so too ; for a slow pulse means slow thought. Nevertheless, there may be firmness, solidity, and soundness of judgment.

The power of resistance to disease is inferior, and the tendency to chronic, and particularly scrofulous, disease is great. This type is said to prevail among the Dutch and Germans, and to be frequently found in England.

The Bilious Temperament. The bilious temperament is supposed to arise from excess of bile in the system, but of this there is no proof whatever. This temperament is in many respects the opposite of the sanguine, and in it other functions are all more active than that of circulation. As a rule, the individuals are dark. The body is spare, though it may be large ; the joints large, the figure angular, the features well-defined, but sometimes coarse. The cheek-bones are high, the eyes hazel or brown —sometimes grey, the lips thick, the jaws firm and strong. The body evinces power and has a strong resisting force against disease. The mind is firm, and often obstinate ; great tenacity of purpose and attachment, the devotion strong, but to few objects. Slow judgment, but not easily shaken, and strong prejudices. In *women* the temperament generally produces firmness of mind, angularity of frame, and hardness of character, with dark complexion and hair.

There is, however, another variety of bilious temperament among women that almost forms a special type. In it the face is slight and more delicate; the hair is smooth, black, and glossy; the character soft and melancholy. They are never stout; the complexion is clear olive, sometimes of marble paleness, and the eyes soft hazel. The temper is docile, indolent, and of unchanging affection and constancy.

The Nervous Temperament. The last temperament is the nervous, and while in two of the other temperaments the names do not afford a reliable clue as to their cause, in this it does. The nerves and intellect here predominate over the body. The skin may be dark and earthy, or pale, or delicately tinted with pink; in fact, of any shade. It is often hot and dry. The skull is large in proportion to the face, the muscles spare, the features small; the eyes quick, large, and lustrous; the chest narrow, the circulation languid, the veins large. The face is characterised by energy and intensity of thought and feeling; the movements hasty, often abrupt or violent, or else languid. The hands and feet are small, the frame slender and delicate. The nervous require sleep, but drink much tea; they are prone to all nervous diseases, and invariably appear able to do more than they are doing.

The character may be, on one side, admirable for its power of mind and insight, for its lofty imagination; while, on the other, it may be disfigured by impetuous and unruly passions. To this class belong the most intellectual of the race, the wittiest, the cleverest of mankind. These are the poets, the men of letters, the students, the professors, and the statesmen. Their great dangers consist in uncontrollable passions. They feel pain acutely. Nevertheless, they can endure long fatigue and privation better than the sanguine. They form the leaders of mankind.

Among women there is delicacy of organisation, quickness of imagination, and fervour of emotion, a temperament of the greatest interest and fineness, but beset with danger for want of a firm control of its great powers.

Environment and Ill-health. Environment is the next predisposing cause, and includes the work or occupation, and the situation as to climate and soil, and town or country. It is obvious, besides the special danger of noxious trades, that a man's occupation has a great bearing on his health; and it is also clear that climate, soil, and locality have the same. As these subjects have already been treated in the section on HEALTH they are not enlarged upon here. One fact is enough to show their enormous importance. If two young men start life at twenty, the one as a town and the other as a country labourer, the latter will, on an average, live twenty years longer than the former, a fact which gives an additional force to the cry of the social reformers—"Back to the Land."

Previous disease is a constant predisposing cause of ill-health. Pneumonia, rheumatism, cholera, epilepsy, influenza, tonsilitis, are, for example, all prone to recur. Other diseases may not recur, but may predispose to other diseases, as whooping-cough to measles, and vice versâ. Or a disease may leave some special weakness behind it that may thus prove a danger.

The Five Laws of Nature. We will turn now to the *five exciting causes* of diseases, which are, in fact, the breaking of the five laws of health—food, air, cleanliness, clothing, and exercise and rest.

Bad food and drink is actually responsible for the loss of some 2,000 lives a week, and is the exciting cause of most internal organic diseases, as well as of the self-made poisons of the blood, such as gout, rheumatism, etc. About three-fourths of infant mortality is due to this one exciting cause. With regard to alcoholic excess, about one-tenth of all deaths arise from it, 120,000 people dying annually from this cause in one way and another, while its direct victims number 1,000 and more a week.

Impure air includes all germ-laden atmosphere, and causes infectious diseases. Changes of temperature in the air are also a cause of chills of various organs, with their attendant evils.

The absence of cleanliness in drinking water is the chief if not the only cause of typhoid fever and cholera. Personal cleanliness, or rather the want of it, lead to many forms of ill-health.

Improper clothing of various sorts is the cause of many ills, especially among women.

Want of Rest. Finally, the want of proper exercise and rest, or their excess, cause many diseases. It is hard to say which of the two most conduces to ill-health—want of exercise or want of rest. Nearly all functional diseases, as opposed to organic, arise from some breaking of this last law; and perhaps nowadays, in these high-pressure times of sedentary occupations, they form one of the chief causes of ill-health. Excess of work frequently goes with too little rest, and constantly produces breakdowns.

The only addition that need be made to these five chief exciting causes is accidents, which we shall consider later.

Before closing this general survey, it should be carefully noted how very preventable all these ten causes of diseases are. In the predisposing causes we must remember the disease is not actually produced. At most, only the train is laid for it, which need never be fired. The exciting causes, one and all, are preventable.

Few need eat bad food, or drink to excess, or breathe foul air, or drink dirty water, or wear insufficient clothes, or deny themselves sufficient rest. The more one looks at this list the more apparent is it that our health is far more in our own hands than we ever supposed. Bad health is almost invariably the outcome of ignorance, carelessness, wilful neglect, or superstition.

Continued

TURKEYS, GEESE, AND DUCKS

Good and Bad Points in Turkeys, Geese, and Ducks. How to Mate, Breed, and Rear these Birds for the Market

continued from page 5626

By Professor JAMES LONG

The Turkey. The varieties of turkey common to this country are the American Bronze, originally produced by the aid of the wild turkey, the Black Norfolk, and the Cambridge, the plumage of which is of a mixed character. Birds of the two latter native breeds seldom, if ever, exceed 30 lb. in weight, while the Bronze has, in this country, exceeded 45 lb., the writer having once exhibited a bird which scaled 43 lb. Good cockerels of a year reach 25 lb., while pullets have attained as much as 17 lb. The Bronze variety has been, in many cases, crossed with our native breeds, but it is still the largest and handsomest of the turkeys of this country, and has made breeding and rearing for the Christmas market a profitable industry. There are also White and Buff turkeys, but neither variety is bred to any extent, chiefly owing to the smallness of the weight attained.

Good Points in Form and Colour. The turkey should possess a long breast-bone, a deep and well-rounded body, the upper line of which is slightly curved, while the breast is broad and deep. There should be plenty of length in the leg, well developed thighs, and a capacity to attain heavy weights in the first year. The *Bronze* turkey [83] is not only lustrous in colour, but displays a variety of tints, especially in the sunlight, these being chiefly bronze. The colour of the tail differs from that of the body, inasmuch as it is black, somewhat indefinitely pencilled with brown, each feather being crossed with a black, broad stripe which finishes with a lightish fringe at the end. The colouring of the hen is never so brilliant as that of the cock. In all the dark varieties of turkey the eye is hazel in colour, while the face, wattles, and head-gear, known as the "caruncle," are all of a brilliant red in the healthy adult. The *Norfolk* turkeys are black throughout, and the *White* and *Buff* without any other shade of colour.

Avoiding Confinement. Where turkeys are bred, they should be kept apart from every other kind of poultry. They thrive best upon dry soil which is well sheltered, but which is not low lying, and the larger their run or the greater their liberty, within reason, the better. One difficulty is their aptitude to stray, and to lay their eggs where they cannot be found. Turkeys do not thrive in the ordinary poultry house. When there are farm buildings they maintain much better health if permitted to roost on the rafters, under the roof, or still better on the branches of pine trees in a small plantation close to their home. Thus, contrary to general belief, the turkey, which is delicate as a chicken, thrives better when exposed to the open air than when kept in confinement.

Breeding. The best and hardiest young stock are bred from birds which are two or three years old. If possible, cockerels and pullets should not be employed for reproduction. The constitution of their young is never so strong, nor are the weights obtained so great as when adult birds are mated together. It is impossible to beat a breeding pen composed of three-year-old hens mated with a two-year-old cock. The male birds should never be too heavy, and although like produces like, it is wiser to employ large-framed hens and adult cocks of a size slightly above the medium, but they should not be fat. Hence, the importance of giving them free range, and of withholding fattening food. If the hens are too fat the eggs they lay will be few in number, while if all the birds are in prime vigour and what we may term store condition, eight to ten hens may form the breeding pen. The number of eggs laid by turkey poults (pullets) and hens varies from 30 to 60, or even more, although the larger numbers are seldom obtainable, for the reason that few, if any, efforts are made to retain the best layers for stock purposes, owing first to the importance attached to size, and next to the difficulty of ascertaining which hens lay the eggs that are found. The turkey prefers a nest of her own selection in a secluded spot, and is not easily induced to lay in a house, much less in a trap nest, for which reason many eggs are lost where the birds have a free range. It is, however, a good plan to provide nests in outhouses and in corners where they can be covered carelessly with brushwood, or any material which will help to conceal them. Where hens lay in nests of their own selection, they usually sit in them when broody, but many hens are less sensitive and excitable, and may be set upon eggs provided by the owner.

The Need for Cleanliness. Young turkeys suffer, perhaps, more than any other variety of poultry from the attacks of parasites, which, if numerous, are the cause of many deaths among them. For this reason, not only should the nests be made in clean spots where there are no vermin, but the hen herself should be carefully examined and dusted with insect powder or any simple insecticide, that she may not be the means of communicating parasites to the chickens as they are hatched. When the eggs are placed in the nests they should be so marked that they may be distinguished from others which sitting hens occasionally lay. The young birds may be expected on the twenty-eighth day.

Rearing Young Turkeys. After hatching, the hen and her young should be placed in a large coop, well sheltered, on a dry and absolutely pure soil, where no poultry have been before. Great care must be exercised during the first fortnight, and special precautions taken against two difficulties—the attacks of vermin, which are frequently found upon the head of the young, and diarrhœa, which is often caused by dirty water, irregular feeding, or improper food. At the end of fourteen days the birds may have their liberty, unless it is possible for the hen to lead her brood into the wet grass, which is often fatal to one or more of her young; but in no case should close and continuous cooping be resorted to.

As regards food, that supplied may consist of chopped egg and breadcrumbs, followed by dry curd produced from new milk; bread sopped in milk, followed by rice, wheat, or groats, boiled or soaked in milk until quite soft; oatmeal; and an occasional sprinkling of hard grain, which, however, had better not be given until three or four weeks after hatching. Green food may consist of chopped lettuce, cut grass, and dandelion leaves, which were strongly recommended by the late Lewis Wright, a high authority on the subject. The birds should be fed often, but the food supplied should be little at a time. As the birds increase in size, they may receive larger quantities of meal mixed with skim milk, especially ground oats and toppings, cracked maize, wheat, finely smashed fresh bone, which is better than bone meal, with milk to drink, while they should be encouraged at the earliest opportunity to roost in the open.

When young turkeys are ready for finishing off for the market their liberty should be restrained, and they should be fed more freely; the meal provided for their rations should be mixed with milk, and if deemed necessary with small quantities of fat once daily. Under normal conditions the birds will not need either cooping or cramming; but it will not be found to answer to feed them on a fattening ration and at the same time to give them a free range.

Some Useful Geese. The varieties of geese known in this country are the White Embden, the Grey Toulouse, the Canadian, and the Sebastopol, with its curled or frizzled feathers. The two former breeds, however, being alone useful are those with which we have to deal. The *Embden* goose [86], which is a more rapid grower than the *Toulouse* [88], while its feathers are more valuable, is orange-coloured in the bill, legs, and feet, while the plumage is white throughout. It reaches great weights, the gander having exceeded 30 lb., while the geese have reached from 22 lb. to 24 lb. The Toulouse goose, also provided with an orange bill, legs, and feet, is chiefly grey in plumage, the wings and beak being edged on each feather with a much lighter shade approaching white. The neck, wings, and breast are grey, the tail being white banded with grey. While the weights of ganders exhibited at some of our great shows have reached from 35 lb. to 38 lb., pairs of Toulouse have reached over 60 lb., but birds of this size are too fat for all practical purposes, and the many we have seen in the past were really kept for prize-taking.

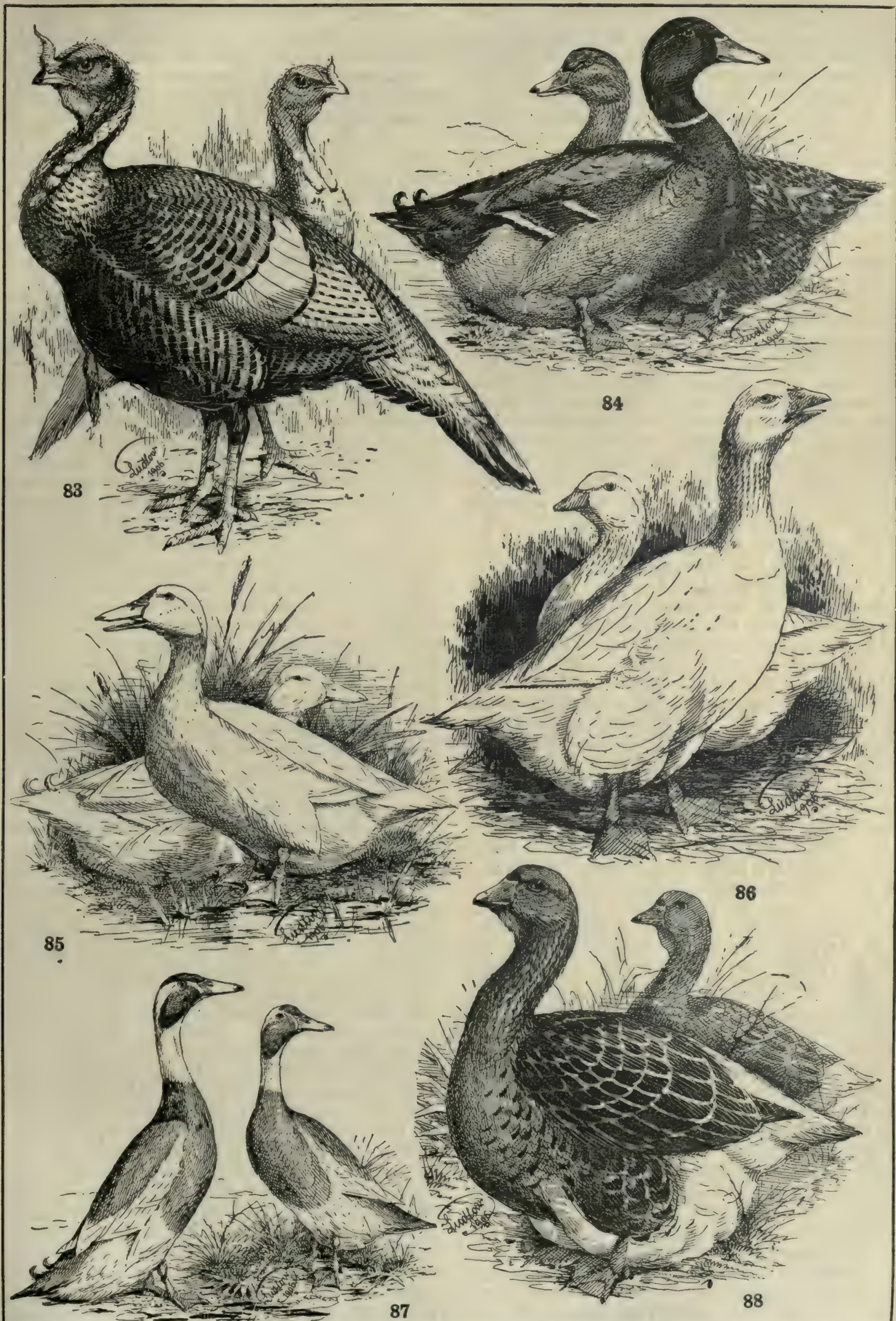
Geese live to a great age, but their economical properties do not often extend beyond ten years. The number of geese kept in this country is not very large, while it diminishes with the enclosure of commons and waste places upon which labourers and other country people in humble positions have bred geese for a long period. With a wide range, they practically find their own livelihood, after the first two or three weeks from hatching, inasmuch as they are close grazers, for which reason it is not advisable to turn them into a pasture with large farm stock, for a number of geese quickly eat down the herbage close, and at the same time soil it.

Feeding Goslings. The goose sits at the outside thirty days, although the goslings often hatch a day or so earlier. Hens are often used for hatching, but they need not be retained with the young goslings after the expiration of a fortnight, when the youngsters can take care of themselves. Goose eggs also hatch well in an incubator, and the goslings may be reared in appropriate brooders with greater ease than chickens. In the ordinary way the goose or hen and young should be cooped for ten days on a dry spot well sheltered from the sun, after which the birds may have their liberty. The food first supplied to goslings is similar to that supplied to chickens and ducklings—chopped eggs and breadcrumbs, followed by oatmeal, barley meal, toppings mixed with milk, and occasionally with boiled potatoes, soaked grain, and chopped or boiled greens. A few weeks after hatching, hand feeding may be gradually diminished, for as the birds begin to take advantage of their liberty, they graze with freedom, and soon find all the food they require, if obtainable. If they are to be fattened, they may be turned upon the stubble when corn harvest has been completed, or hand fed with maize, oat, or barley meal with some liberality. They require a roomy, well-ventilated house, the floor of which should be bedded with straw. Water is not essential to the maintenance of geese, but it is useful; although, when fattening their daily swim should be stopped.

In breeding, three geese may be mated with a gander in the month of January or early February. They should be in store condition—*i.e.*, not fat—and goslings of the previous year should not form part of a breeding flock. The eggs laid vary from fifteen to twenty-five, and are frequently laid in two batches, so that many persons refrain from allowing a goose to sit until she has laid her second batch.

The demand for geese among the best class of consumers is comparatively small, but large numbers of Irish bred geese find their way to this country, and are sold from Michaelmas to Christmas at somewhat low prices—prices, indeed, which would not pay the ordinary English producer.

The Best Ducks. There are several breeds of duck known in Great Britain, although the varieties kept for producing food are practically confined to the Aylesbury, the Rouen, the Pekin, and the Indian Runner. The *Aylesbury*



TURKEYS, GEESE, AND DUCKS

83. Bronze Turkeys 84. Rouen Ducks 85. Aylesbury Ducks 86. Embden Geese 87. Indian Runner Ducks 88. Toulouse Geese

duck [85] possesses purely white plumage, a flesh-coloured bill, and orange legs and feet. It is an economical bird of great value, laying a large number of pearly-white or green eggs, and producing meat of the finest quality.

The *Rouen* duck [84] closely resembles the mallard in plumage. The bill of the drake is a yellowish green, with a black mark resembling a bean at the tip, while that of the duck, which possesses the same mark, is also marked with black on the centre on an orange ground. Briefly, the Rouen drake has a metallic-green head, a white ring round the neck, a claret-coloured breast, French grey flanks, which are delicately pencilled, and metallic purple wing bars, merging into black at each end, and then fringed with white. The tail is brownish black, some of the feathers curved, as in all males of British varieties, the Muscovy excepted. The legs and feet are of a reddish colour.

Importations from Other Climes. The *Pekin* duck, which was introduced into this country about thirty years ago, has orange legs, feet, and bill, while the plumage is a canary-tinted white. The Pekin has a large head and a short bill, while the body, which has considerable breadth, is carried very upright. The duck lays a large number of fine eggs, an average of 150 per annum having been reached. The *Cayuga* duck is of American origin, but has been improved in size and colour by crossing in this country. It is almost as large as the Aylesbury ; the plumage is a rich, metallic, lustrous black, while the beak is of a black slate colour at the sides and dense black in the centre. The *Muscovy* duck, which has little to recommend it, is remarkable on account of the difference between the size of the male and the female, the former scaling from 10 lb. to 12 lb., and the latter 5 lb. to 6 lb. The duck is a bad layer, and the breed cannot be recommended for the table. The *Indian Runner* duck [87], which, like the Pekin, is very upright in carriage, and weighs from 4 lb. to 5 lb. at the outside, is a hardy bird, a great forager, and a most excellent layer, producing from 100 to 120 white eggs per annum, and finding most of its food. In colour it is fawn or grey and white, the marking being very exact, while the bill of the adult bird is green, with a black bean mark, and the legs and feet yellow. Among fancy ducks most generally recognised at the exhibitions are the black *East Indian*, the *Mandarin* and the *Carolina*. For economical purposes, the best duck is, perhaps, that produced by a cross between the Aylesbury drake and the Pekin duck, the latter having a larger frame, and producing larger eggs.

Breeding Ducks for the Table. Duck breeding for the table is now conducted on a considerable scale, many persons producing several thousands in a year. The best markets extend from February to May, and those who provide for them in large part make a practice of purchasing eggs from November forwards, or hiring or purchasing pens for hatching, or of employing incubators. For breeding stock water is essential, many eggs being otherwise unfertile, but young birds intended for fattening are not allowed to swim. Breeding birds, which should not be fat, thrive best when at liberty, especially where there are ponds and ditches in which they can find plenty of animal food.

Housing and Rearing Ducklings. Ducks should be kept in their house until after laying, otherwise they are apt to lay away, or even in the water. The house should be dry, abundantly ventilated, and bedded with straw. It is usual to mate from four to five ducks with a drake, but birds of the previous year are better avoided, mature stock producing the strongest and largest ducklings. When the young birds are hatched, the first food may consist of chopped egg and breadcrumbs, followed by boiled rice, chopped meat, dry curd, and chopped lettuce ; and in a few days these foods may be varied by a ration of oats given in a small vessel of water which the birds cannot enter. In three or four weeks the meat ration is increased, and as the ducklings are intended for marketing at from eight to ten weeks—at any cost before moulting begins—they are liberally supplied with meal, mixed with milk and fat, with some finely-cut bone or butchers' offal. Many feeders use as fat the greaves produced by the tallow chandler. At nine weeks the birds should reach 4 lb., and as a guinea a couple is sometimes realised in the best season, although the average price throughout the year may be nearer 4s. per bird, it follows that rapid feeding—which means liberal feeding—is the most economical. Although ducks sometimes reach, and in the case of the Pekin exceed, 10 lb. in weight, they are of little use for breeding, stock ducks varying from 6 lb. to 7 lb. at the outside. Where ducklings are bred and fed on a large scale for market, they are kept in companies of 50 to 100. Ducks are hardier than chickens, and few are lost under normal conditions, but carelessness, dirt, exposure, and bad food may cause diarrhœa.

The Guinea Fowl. The common guinea fowl kept in this country for egg and meat production has a knob or helmet on the head, and red wattles or gills, the plumage being a purplish blue grey, with white spots evenly distributed throughout. It is fine in the bone, weighs about 3½ lb., and produces small eggs of extremely rich flavour and delicate meat of fine quality. The young chickens are not very hardy, and they require frequent feeding on egg, breadcrumbs, crushed grain, and finely chopped meat, which they especially need. They should be kept in a confined run in the air until they are large enough to be liberated. As they grow they will forage like adult birds, and soon find all their own food, although they will respond to the call and feed with hens. They are apt to lay in hidden nests, from which cause many eggs are lost, but by careful training when young they may be induced to lay in house nests. It is a good plan to allow them to roost in trees, especially old firs or yews, near the poultry yard, as they are most excellent watch dogs, screaming in their peculiar way when disturbed at night. The hen lays from 60 to 70 eggs, while the young hatch in from 26 to 28 days, hens being usually employed for incubation.

Continued

EUROPE IN DEVELOPMENT

Economic Regions of the Russian Empire. The Siberian Railway. Rumania. Bulgaria. Servia. Scandinavia. Austria-Hungary

Continued from page 5664

By Dr. A. J. HERBERTSON and F. D. HERBERTSON

WE now turn to those European lands which are still in an early stage of industrial development and international trade on a large scale. Russia is by far the largest of these, and consequently possesses far the greatest potentialities. It is the greatest continuous land empire in the world, with an area of 8,000,000 square miles, containing a population of over 140,000,000 people [see GEOGRAPHY, pages 2406–9 and 2715–19]. In position and products it may be compared with Canada, but it is two and a half times as large, and its population is twenty times as great. It differs from its Canadian prototype in its western or European portion, and in Transcaucasia, Transcaspia, and Turan it exhibits a type markedly unlike anything in Canada.

The Four Zones of Russia. The four characteristic zones of tundra, forest or taiga, steppe, and desert have already been described. Except on its arctic and forest margins, both of which produce furs, the vast barren region of *tundra* is as yet economically valueless. Gold, however, is abundant in the north-eastern portion of Arctic Russian Asia, and, as in the corresponding Yukon region of Canada, will probably lead to a considerable development of mining enterprise.

The *taiga*, or forest zone, is already exploited to some extent for timber, wood-pulp, and other forest produce. In the main, however, it is a vast undeveloped asset. Wood is used for domestic purposes, as fuel for locomotives, and to feed the smelting furnaces of the Ural mining district.

The Mineral Wealth of the Forest Zone. The mineral wealth of this zone is considerable. It is greatest in the province of Perm, where it has long been exploited. Gold (in the Tura and Tagil valleys), platinum (now the most valuable industrial metal in the world), lead, copper, and tin are the chief metals, and Perm, Yekaterinburg (iron mines), Nizhni Tagilskyi (copper and platinum) are the most important mining centres. Magnetic iron ore is found in Finland, where granite quarries and the deposits of kaolin clay are beginning to be utilised by one of the most intelligent populations in Europe. Other mineral centres in the forest zone, which extends right across European Russia and far across Asiatic Russia, are the Altai Highlands (gold and silver), and the eastern mountains of Transbaikalia and Amuria (gold and tin). The Siberian graphite mines at Alibert are the most important in the world. Coal is now mined in the Southern Shenka district, between Tomsk and Maryinsk, in the Kirghiz steppe (where copper is also found), near Irkutsk, in the Southern Usuri region, and in Sakhalin.

In European Russia agriculture is possible, and has long been carried on in the numerous forest clearings. Rye and hemp are the chief crops cultivated, especially in the west in the Baltic provinces, whence most of the hemp supply of Europe is obtained.

Industries in this region, outside the metal smelting already mentioned, are developing around the coalfields of Poland, where Warsaw and Lodz are great cotton centres [see page 2408], and in the Moscow district, the latter using coal from the Oka coalfield round Tula. Moscow, Tver, Yaroslav, and Ivanovo (the latter known as the Russian Manchester) manufacture the raw cotton brought from the irrigated oases of Russian Central Asia. To a smaller extent, manufactures are also important at St. Petersburg and Narva.

A Stock-raising and Wheat-growing Region. The *steppe*, in its primitive economic condition, is a stock-raising region. The climate of the whole region is dry, but in the western part, which has the least scanty rainfall, the fertile black soil, *chernozoim*, is very fertile when cropped. Wheat is largely grown for export, while the cheaper rye supplies the food of the farming population. This may be compared with the similar conditions in India, where millet is the native food, and wheat is grown only for the European market. In both cases this recent development has been made possible by modern facilities of transport, the great magician of the modern world.

The *wheat* of this zone is a very important item in the world's supply. It is carried to the ports of the Black Sea (Ochakof, Odessa, Kherson, Taganrog, Rostof, and others) for export. For reasons explained in the case of Canada, milling is growing in importance at such centres as Odessa, where macaroni is manufactured.

The coal, iron, and manufacturing industries, though only of recent origin, are becoming firmly established in the steppe zone. Coal is mined in the Donets basin, and supplies the linen, tobacco, soap, and sugar manufactures of Kharkof. It is also used to smelt the red hæmatite and specular iron ores of Krovoi Rog, some hundred miles north of Kherson. Kief, on the margin between forest and steppe, manufactures linen and sugar from locally grown flax and beet.

In the irrigated lands of the *desert* zone enormous attention is being paid to the cultivation of cotton, which is sent to the cotton mills of Moscow and other textile centres of the Oka coalfield [see above]. The oil industry has been described on page 2718.

The Value of the Great Siberian Railway. Internal communications are improving year by year. The construction of the great transcontinental line of the Siberian Railway may be compared with the construction of the Canadian Pacific line. The first great step of providing through communication between the extreme east and west of a vast dominion having been achieved, Russia, like Canada, is now pushing on the work of spreading a network of branch lines into the unbroken lands on either side, and is linking up the Siberian line with the Central Asian lines. The examples of the United States and Canada leave no reason to doubt that this will be followed by a rapid extension of settlement—in this case, eastwards—and by the rapid utilisation of what is still, for the most part, an undeveloped asset, though of enormous potential richness.

Russian Exports. The Russian exports are even more difficult to analyse than those of the United States. Russia carries on a Baltic, a Black

Sea, a small Caspian, and a considerable Pacific trade. It has also a large overland trade, especially with the Central European Powers, and with its neighbours in Asia. Statistics distinguish between trade which crosses the European frontier, including the Caucasus, trade with Finland, and trade which goes across the Asiatic frontier. The figures are given in millions of roubles; 1,000,000 roubles is worth rather more than £105,000.

Year	Trade across European frontier and Black Sea frontier of Caucasus	Trade with Finland	Trade across Asiatic frontier	Total
1902	787·2	38·0	35·1	860·2
1905	954·4	38·3	54·3	1047·0

Excluding trade across the Asiatic frontiers, the following are the exports for 1904, the last year for which complete figures are available.

Class of export	Value in millions of roubles	Percentage
Articles of food	614·9	64·4
Raw and partly manufactured goods	300·8	31·5
Animals	16·1	1·7
Manufactured goods ..	23·2	2·4
Total	955·0	100·0

These figures may be compared with those for Canada, with which they present a general similarity, though animals and manufactured goods bulk larger in Canadian than in Russian exports. Of the articles of food exported from Russia, wheat is much the most considerable item. The principal raw and half-manufactured goods are timber and wooden goods from the forest zone; naphtha from the oil districts; and flax from the agricultural zone. Raw cotton, to the value of 18·5 million roubles, and sugar, to the value of over 11·5 million roubles, are the chief exports across the Asiatic frontier.

Imports. Taking the same classification of commodities as for the exports, the following were the imports into Russia in the same year, 1904.

Class of import	Value in millions of roubles	Percentage
Articles of food	92·5	15·9
Raw and partly manufactured goods	332·8	57·0
Animals	1·5	0·2
Manufactured goods ..	156·7	26·9
Total	583·5	100·0

In the first group, tea is first in value, followed by wine and spirits among the foods. Raw cotton is by far the most important import, accounting for more than one-sixth of the total value of the imports. Raw metals, coal, wool, and gums and resins are the next in order of value among the raw and partly manufactured goods. Machinery, metal goods, and textiles are the principal manufactured articles imported. Compare, again, with Canada.

Across the Asiatic frontier the imports are tea from China, but in diminishing quantities; rice from Persia, and raw cotton from Russian Central Asia, the latter in increasing quantities.

Countries with which Russia Trades. As might be expected, the German Empire is Russia's best customer, the trade passing both overland and by the Baltic. The United Kingdom is second, sending in coals and manufactured goods in exchange for timber, hemp, flax, and some cereals, through the Baltic ports, and receiving large quantities of cereals through the Black Sea ports.

The following table indicates the value of Russia's trade with some of her most important customers.

Country	Imports from	Exports to	Total
	Millions of roubles	Millions of roubles	Millions of roubles
Germany ..	225·0	234·0	459·0
United Kingdom	102·5	230·8	333·3
Netherlands ..	11·2	99·0	110·2
France	26·0	61·9	87·9
Finland ..	24·5	46·3	70·8
United States ..	62·5	4·3	66·3
Austria-Hungary	21·4	40·4	61·8
Egypt	15·8	4·3	20·1
China	19·0	2·4	21·4

Notice the distribution between imports and exports in the case of the United States, Egypt, and China. The explanation in the case of the two first is cotton, in the last tea.

The Scandinavian Lands. Sweden and Denmark broadly resemble the other Baltic lands, Western Russia and Northern Germany. They consist of morainic lake-lands, interspersed with peat bogs. Forests are numerous, and timber, joinery, wood-pulp, and resins are among the exports. Agriculture is carried on in the clearings of Southern Sweden, and dairy farming (butter, cheese, eggs, bacon) is a staple industry of Denmark. Sweden possesses rich deposits of iron ore at Dannemora and Gellivara [see page 1562].

Sweden. Nearly half the population (45 per cent.) of Sweden live by farming, a quarter by manufactures, trade, and transport, and six per cent. by mining. The manufacturing classes are engaged chiefly in iron, steel, and engineering works, textile factories, sugar mills, and sugar refineries, breweries, flour mills, and tobacco factories. The trade of Sweden is summarised by the tables for 1903, given below, in thousands of kronor; 18 kronor equals £1.

Exports	Value in thousands of kronor	Imports	Value in thousands of kronor
Timber	228,331	Minerals, mainly coal	86,033
Live animals and animal foods..	49,507	Metal goods and machinery ..	63,484
Metals	40,393	Wheat and flour	60,938
Metal goods and machinery ..	32,461	Textiles ..	91,318
Minerals ..	31,825	Colonial produce	35,570
Paper	18,381	Live animals and animal foods..	26,971

The overwhelming importance of timber in these returns is obvious. Next come animals and animal foods, and minerals and mineral products.

Most of the Swedish exports go to Britain, especially those of timber, butter, wood-pulp, and iron. Most of the imports come from Germany, but the total trade with the United Kingdom is greater than that with Germany, Denmark, Norway, Russia, the Netherlands, and Belgium, all put together. In 1903 the total value of the exports was 441,417,000 kronor, and the total value of the imports 534,902,000 kronor.

Trade of Denmark. The trade of Denmark well illustrates the uniformity of the country and the remarkable economic development of recent years. In 1904 the exports of the home produce were worth 358,629,000 kroner (18 kroner equals £1), and of this, eggs accounted for 278,927,000 kroner, and animals for 37,455,000 kroner.

The position of Copenhagen on the Sound, at the point of vantage between the North and Baltic Seas,

makes Denmark a relatively important trading country. In 1904 its total value export trade was worth 497,836,000 kroner, of which home products formed only about 72 per cent. Over 56 per cent. of this trade went to the United Kingdom, 21 per cent. to Germany, and 10 per cent. to Sweden and Norway.

The import trade of Denmark is largely in cereals (14 per cent.), textiles (11·5 per cent.), metals and hardware (9 per cent.), colonial produce (7·5 per cent.), and coal (6·5 per cent.), the latter not being produced in the country. The total value of the import trade in 1904 was 292,147,000 kroner. A remarkable feature of the trade returns is the import of provisions and eggs, which accounts for 12·5 per cent. of the total import trade. These are collected from the other Baltic lands, to be shipped to Britain and other countries through Copenhagen.

Over one-third of the imports (35 per cent.) come from Germany, and only 15 per cent. from Britain. Russia and the United States each contribute 12·5 per cent. of the total imports, and Norway and Sweden together, rather more than 10 per cent. Its flourishing provision trade, the staple of its prosperity, is the result partly of the climatic conditions, and partly of the excellent technical education given to its people. Its entrepôt trade is sufficiently explained by its position.

Norway. Norway, the rugged land which occupies the western highlands of the Scandinavian peninsula, differs completely from Sweden and Denmark in configuration and climate. Its economic conditions are correspondingly different. Three-quarters of the surface of the country is unproductive, and of the remaining quarter, 22 per cent. is forested, leaving only 3 per cent. fit for cultivation. Under these conditions, maritime occupations (fishing, shipbuilding, the carrying trade, etc.) naturally rank among the principal industries of the country. Thirty per cent. of the population are engaged in agriculture, but to a very large extent these supplement their resources by fishing.

The figures for the export trade of Norway show how much the prosperity of the country depends on the fisheries and the forests. The figures for 1904 are given below. The kroner has the same value as above.

Exports	Kroner
Timber and wooden goods	61,697,000
Animal produce (malty food)	56,293,000
Paper and paper manufactures	10,511,000
Hair and skins	6,818,000
Tallow, oils, tar, etc.	6,746,000
Vessels, carriages, machinery	6,703,000

The import trade of Norway naturally consists largely of breadstuffs, since the country cannot raise its own, and groceries. Metals and machinery also form a considerable item. The figures for 1904 are:

Imports	Kroner
Breadstuffs	52,242,000
Minerals	37,960,000
Vessels, carriages, and machinery ..	30,668,000
Textiles	23,108,000
Metals (manufactured)	20,889,000
Tallow, oils, tar, etc.	18,259,000

Norwegian trade with Britain is far greater than that with any other country, though Germany sends more goods to it than we do. Norway sends to Britain wood and wood-pulp, fish, stones, ice, and in return receives coal, cottons and woollens, machinery and ironwork. Fish is largely exported to Spain, Italy, and other Catholic countries. The mercantile marine has a total tonnage of nearly 1½ million. Compare the German Empire (2¼ million tons), and the United States (3¾ million tons on the ocean).

Rumania. Rumania [see GEOGRAPHY, page 2165] resembles Southern Russia. Its great steppe lands rise to the forested slopes of the Karpathians and Transylvanian Alps, so that agricultural and forest products form the staple of its natural resources; 60 per cent. of the population are engaged in agriculture.

The following table shows the nature of the trade in 1904, in thousands of lei; 1,000 lei equals £40.

Exports	Thousands of lei	Imports	Thousands of lei
Cereals	195,943	Textiles	118,205
Wood	23,512	Metals and Manufactures	82,946
Animal products	11,581	Chemicals and drugs	16,779
Fruits and Colonial produce.. ..	6,998	Fruits and Colonial produce	14,737
Mineral fuel ..	6,212	Hides and leather..	10,074

Cereals, forest produce, animal products, and oils from the petroleum wells are among the chief exports through the Danube ports, the most important of which are Galats and Ibraila. The exports go to Belgium, Austria-Hungary, the United Kingdom (wheat, barley, maize, petroleum, and timber), Turkey, and Bulgaria. The imports are obtained from Austria-Hungary, the German Empire, the United Kingdom (cottons, cotton yarn, iron, machinery, coal and woollens), France, Italy, Turkey, and Bulgaria. The total value of the exports in 1904 was 261,872,000 lei, and of the imports, 311,372,000 lei.

Bulgaria. Bulgaria somewhat resembles Rumania in the north, but it is narrower and less fertile. The chief agricultural area is in the Maritsa and Tunja valleys [see page 2167]. Cereals are exported to the United Kingdom, Belgium, Turkey, the German Empire, Austria, and France, and account for four-fifths of the total exports. The others are livestock and their products, silk cocoons, and attar of roses. Textiles form one-third of the imports, and metals, machinery, and implements one-sixth. The imports come chiefly from Austria-Hungary (nearly 30 per cent.), Germany (15 per cent.), the United Kingdom (14 per cent.), and France (8 per cent.). The imports from Britain are cottons, cotton yarn, machinery, and metals. In 1904 the total value of the exports was 157,619,000 leva (1,000 leva equals £40), and of the imports, 129,690,000 leva.

Servia. Servia is more rugged and forested than Bulgaria, and has a much smaller trade. Animals and animal products formed nearly half the exports in 1904, and agricultural products nearly two-fifths. Nine-tenths of the export trade was with Austria-Hungary. Austria-Hungary thus has an economic control over Servia, which is hardly less valuable than a political one. It has been said, indeed, that Austria's habitual method of curbing Servian advances to other Powers is to proclaim the existence of swine disease in Servia, and to prohibit the export of swine from that country into Austria-Hungary. The chief imports are cotton and woollen goods (27 per cent.), metals and machinery (21·5 per cent.), colonial produce, food, and drinks (8·5 per cent.). Of these, 60 per cent. comes from Austria-Hungary, 13 per cent. from Germany, and only 8 per cent. from the United Kingdom. The total value of the exports in 1904 was 62,156,000 dinars, and of the imports, 60,926,000 dinars (1,000 dinars equals £40).

The Kingdom of Hungary. From an economic, as well as from a political point of view, Austria-Hungary must be regarded as consisting of two groups of Powers. *Hungary* resembles Rumania in many respects, but has a greater mineral and industrial development, in addition to more extensive territories. The fertile plains or pastures of Hungary are no longer exclusively pastoral, but rich agricultural lands; 41 per cent. is arable, and 33 per cent. meadows and pasture land. The slopes of the Karpathians and other mountains are densely forested, so that 28 per cent. of the country is covered with trees. The rocks are rich in minerals, especially in the Bihar region, and in the North Hungarian Ore mountains, where gold, silver, copper, lead, coal, antimony, mercury, and other minerals abound, but are not exploited as they might be. The mineral riches of Hungary will undoubtedly be a greater source of wealth in the near future.

The chief wealth of Hungary is agricultural. On the flat steppe lands rich crops of wheat and maize are grown. The wheat is of extremely fine quality. Much of it is ground by the most modern processes, the different qualities being sorted out beforehand. Hungarian flour is the best on the market, and is better than flour ground in our own country by the same processes from Hungarian wheat. This is probably due to different climatic conditions, and to the effect of the voyage on the wheat. Budapest, Temesvar, and Poszony (Pressburg) are the chief milling centres, and Fiume the chief outport; but some of the wheat is sent down the Danube. Oats, barley, and rye are a'so grown.

Among other agricultural products are potatoes, beetroot, pulses, tobacco, hops, and even a little rice is grown in the Banat. Horses, cattle, pigs, and sheep are numerous. Hungary is noted for its vineyards, and its silk culture supports over 112,000 families.

Hungarian Manufactures. Manufactures are rapidly developing in Hungary. As in Canada, and other lands, where agriculture is expanding, much of the industry is connected with the elaboration of food, agricultural implements, and transportation plant. Thus, Budapest and Poszony (Pressburg) mill flour, and also make jute sacks for holding it, and the necessary machinery and rolling stock. Agram, in Croatia, is noted for its tobacco factories. The following figures show the relative importance of the different manufactures, which occupy 12·8 per cent. of the working population—in clothing, 25 per cent.; in foodstuffs, 14 per cent.; in iron and other metals, 11 per cent.; in building, 11 per cent.; in wood and bone, 8½ per cent.

In 1904, the following was the value of the exports and imports in thousands of crowns (£40), each crown or kroner being equal to 9¾d.

Exports	Thousands of crowns	Imports	Thousands of crowns
Flour . .	199,458	Cotton . .	157,509
Wheat	74,138	Woollen & semi-woollen	101,103
Other cereals	124,167	Wheat . .	21,332
Cattle	136,115	Coal	21,011
Pigs . .	52,233	Silk	20,910
Eggs, etc.	31,429	Pigs	20,654
Wine . .	28,120	Cotton yarn	20,521
		Leather	19,754

This shows the predominantly agricultural nature of Hungary's present prosperity. As might be expected, the imports are largely manufactured goods.

The Austrian Empire. The Austrian Empire [see page 2162] is more diverse economically than the Kingdom of Hungary. It has to be divided into (1) Galician Bukovina, Bohemia, Silesia, and Moravia; (2) Austria proper; (3) Alpine provinces, Bosnia and Herzegovina; (4) Coastal Provinces.

Half the population depends on agriculture and forestry, and about one-quarter on various industries—manufacturing, metallurgic, etc., while nearly 8 per cent. are supported by trade and transport, and over 2 per cent. by mining; 38 per cent. of the land is arable, 35 per cent. is woodland, and 25 per cent. is pasture and meadow land.

Wheat, barley, rye, and oats are all extensively cultivated. Potatoes are a most important crop; vines, maize, pulses, beet (in Bohemia), and vines are next in importance. Considerable areas, especially in Bohemia, are covered with flax, hemp, and hops. Livestock is abundant. In valleys opening to the Adriatic silkworms are reared.

The mineral wealth is mainly coal in Silesia; coal, lead, zinc, silver, alum, and graphite in Bohemia; iron, zinc, and lead in Alpine states; iron, petroleum, and salt are found in the Karpathian foreland; copper is obtained in Salzburg, and mercury at Idria.

Austrian Manufactures and Trade. Manufactures are growing rapidly in importance, especially near the coalfields of Bohemia, Moravia, and Silesia, where iron manufactures are flourishing. Bohemia makes sugar from beetroot, much beer, especially at Pilsen, and brandy; cottons and woollens are manufactured at and round Reichenberg in the north, and linen and leather goods. Bohemia is also famous for its glass and porcelain. Vienna, like Prag and most other capitals, makes many articles of luxury, more particularly furniture, silk and dresses, and boats for the Danube. Paper is made in the forested Alpine provinces and Northern Bohemia.

The trade of Austria with the East consists of the exchange of manufactured goods for food and raw materials; but with the West it is rather an exchange of raw and half-manufactured goods for finished wares. The down-Danube trade is with Hungary and the Balkans, the up-Danube trade with South Germany. From Bohemia, trade passes by the Elbe valley to a North Sea outlet. Austria has its own port in Trieste, on the Adriatic, with connections especially with Mediterranean and eastern ports.

Austria-Hungarian Trade. The trade of Austria-Hungary is five-sixths by land and one-sixth by sea. Naturally, most is with the adjoining lands of the German Empire, Italy, Russia, Switzerland, and the not-far-distant France. British trade is largely through the Adriatic ports, and ranks second.

The exports and imports of the Common Customs Territory, which includes Austria-Hungary, the occupied territories of Bosnia, Herzegovina, and also the Principality of Liechtenstein, are:

Exports—1904	Thousands of crowns	Imports—1904	Thousands of crowns
Sugar	151,885	Cotton (raw)	215,226
Eggs	105,567	Wool	129,888
Cattle	98,617	Coal, coke, etc.	105,947
Horses	61,476	Silk and manufactures	83,499
Lignite	61,320	Hides and skins	63,461
Woollens	58,346	Machinery	52,636
Glass	56,945	Tobacco	52,624
Malt	52,910		

Continued

CLOCK MANUFACTURE

The Works of a Clock. Taking to Pieces, Cleaning, Repairing, and Fitting together again

By JOHN P. LORD

OF all the callings which are practised actually in the sight of the multitude, perhaps none has such a fascination for the ordinary individual as that of a watch and clock maker, and yet it is surprising how little the general public really knows of the trade, or of the works of their own timepieces. To the child the watchmaker is a man who "makes the wheels go round," or who works in a shop window with an eyeglass in his eye, and covers up things with broken wineglasses. In later life the mystery of the craft is little better understood, and the watchmaker becomes a highly-skilled workman to whom periodical bills have to be paid. England was once the home of this industry, but the free importation of countless cheap foreign and American clocks and watches has seriously affected the trade, though the best and most reliable timepieces are still to be sought for in British workshops.

Without further preamble, let us begin to initiate ourselves into the rudiments of this fascinating trade, and as the beginner, or his parents, will not wish to spend money on experimental training until a distinct taste for the work is discovered, we shall take as our first subject for examination one of those cheap American clocks which can be bought anywhere for about half-a-crown.

Our First Steps. Having purchased your cheap clock, or got hold of an old one, you will have to provide yourself with tools, and at this stage very few will be required. A small screwdriver, or, what is probably better, a large bradawl to act as such, is the first requisite. A pair of flat-nosed pliers, a pair of tweezers, with fine points and with absolutely plain inner surfaces, such as artificial flower makers, printers, or clockmakers use, and a pocket-knife complete the preliminary outfit. The whole set need not cost more than 3s., and if the trade is not followed up, the instruments are always useful.

First place your tools beside you on your right hand, and before you lay a large sheet of white paper. Take the clock in your left hand, and remove the winding handle by turning it the contrary way to the winding direction. In most American clocks this is from left to right. Then pull off the setting thumbscrew, which is only forced on to the spindle. If the clock has an alarum, the winding handle for that must be removed in the same manner, save that it generally unscrews in the opposite direction to the other winder, and the knob for setting the alarum must be pulled off. If the setters will not budge, a little prizing with the screwdriver or the pocket-knife will generally start them. Unscrew the legs and the knob, or knob and bell, at the top. If there are any tiny screws round the edge close up to the back, these must be removed, but if there are only three little dents or bulges, all is ready for taking off the back. This must be levered up with the screwdriver, when the entire movement will be visible. Examine the inside of the case, and see if any pin or screw is holding in the works and the dial, and, if so, remove it, then pull out the clock from the case, when it will come quite clear, bringing the dial with it. Next examine the back of the dial, and probably you will find that it is held on by two small pins. These should be taken out, first making them straight, and then the hands must be taken off. This is not a difficult job if you work the edge of the knife under the centre on one side, and the screwdriver on the opposite side, and then carefully prize the minute hand off. The hour hand works round on the same spindle, but is mounted on a little brass tube. The operation repeated will remove this, and if the clock has a seconds hand that must be taken off, as well as the alarum indicator when present. The dial will now drop off, and behind it will be found a metal rim. Through the openings in this rim you will see the two steel screws which hold it in place, and when these are turned out the entire movement will be quite clear.

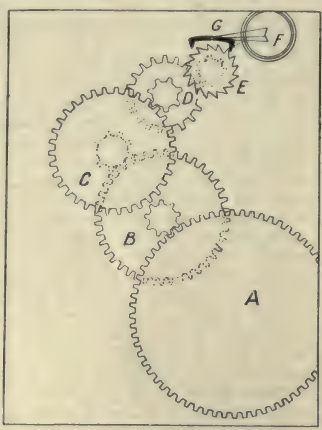
The Motion Work. When you hold up the clock in front of you now, with the hands replaced you will see outside the brass framework several toothed wheels. On examination, you will notice that the hour hand rides on the shank of the centre large wheel, and therefore you know that the large cog-wheel must turn once in 12 hours. You also know that the pin on which the minute hand works, and which turns it must turn once in one hour. Trace this pin backwards into the clock, and you will see that it forms the spindle of the second largest wheel, known in the trade as the *centre wheel*. Accordingly the centre wheel must turn once in one hour. From this we can learn our first fundamental fact in clockwork—namely, how to accelerate or retard motion.

Remove the hands again, and you will find that the large middle wheel in front of the frame can be pulled off the same spindle on which the minute hand was fixed, for it slides round it quite freely, and beneath it you will see a little star-shaped wheel with 12 teeth. This is not really a wheel, but is cut out of a piece of solid brass. Little wheels of this form are known as *pinions*, and the one we are looking at is called the *cannon pinion*. It fits firmly on the centre spindle, which is called the *centre arbor*—the spindles of clock and watch wheels being known as *arbors*—and accordingly turns once in one hour, just as does the minute hand.

This cannon pinion, as you will readily see, turns a wheel having 36 teeth round its edge, and so it will take three turns of the cannon pinion to turn this wheel once, or, in other words, this second wheel turns once in three hours. This wheel is known as the *minute wheel*, in spite of the long time it takes to turn. The minute wheel turns freely on a pin, and has no arbor itself, strictly speaking. On the top of it you will find, fastened firmly to it and turning with it, a pinion with 10 teeth, but otherwise similar to the cannon pinion. This pinion, of course, turns once in the same time as the minute wheel—namely, in three hours, and its 10 teeth, or *leaves*, as pinion teeth are termed, drive a wheel of 40 teeth, as you can prove for yourself by replacing the large middle wheel which you have removed, when you will find that its teeth engage in the leaves of the minute-wheel pinion. Now, since 10 divides into 40 four times, the middle wheel

will take four times as long to turn once as the pinion driving it does. Since the pinion turns once in three hours, naturally the centre wheel will turn once in three multiplied by four hours, or in 12 hours, and on again replacing the hands you will understand how the arbor of the centre wheel of the clock is made to turn the hour hand as well as the minute hand. This middle wheel is called the *hour wheel.*

The same principle applies all through the science and art of clock and watch making. The speed of a wheel is reduced by having it driven by a wheel with fewer teeth, and the converse also applies — namely, a wheel with many teeth will drive one with fewer faster than itself. The rates in proportion can be obtained by dividing one set of teeth or leaves into another. For instance, if we have a wheel turning once in one minute and we want to turn once in 10 minutes: if we put a pinion of six leaves on this one-minute wheel and make it drive a large wheel with 60 teeth round its edge [1], the second wheel will turn once in 10 minutes because 60 is 10 times six. Again, if we want a wheel turning once in seven minutes to make another turn once in one minute we can put 35 teeth round the first wheel, and make them drive a pinion with five leaves on the arbor of the second wheel, for five is the seventh part of 35, and, therefore, the pinion will turn seven times for one turn of the first wheel. This principle of arranging wheels must be thoroughly mastered, for half watch and clock construction depends upon it.



1. TRAIN OF COMMON AMERICAN CLOCK

A. Great wheel and spring B. Centre wheel C. Third wheel D. Fourth wheel E. Escape wheel F. Balance G. Pallets and lever

The Movement. Having the motion work outside the frame, we shall next turn to the inside of the clock. Turn the clock so that the little balance-wheel, which keeps swinging to and fro, is on the top, and the motion wheels facing you. Pull off the motion wheels to give you a clearer view. At the bottom right-hand corner you will see a large wheel with a spring attached to it. This is the *great wheel*, and is the motive power of the clock, for, contrary to the popular opinion, the balance wheel does not "make the clock go," but acts as a brake or drag to prevent the clock from running quickly down with accelerating speed. The spring, when wound up, fits tightly against the arbor of the great wheel, and its nature is to uncoil, in doing which it turns the great centre wheel.

You will notice that the edge of this great wheel drives a pinion on the centre wheel, turning the latter once in one hour, so by counting the leaves of the pinion on the centre wheel arm and dividing them into the number of teeth on the great wheel you will know how often the great wheel turns in a day. In the cheap clocks which we are considering the great wheel generally has 48 teeth, and the pinion on the centre wheel has 8 leaves, so the great wheel turns once in 6 hours, or four times in a day.

In these clocks you will notice that the pinions inside the clock frame are different from those in the motion work, being made of two plates of brass joined together by a number of steel pins. These pins act as leaves for the pinion, and this form is known as a *lantern pinion*, from its appearance. It is a very good pattern for pinions which are driven by larger wheels, but is unsatisfactory when the pinion is used to drive a large wheel. In the trade, wheels which make others turn are known as *drivers*, and those which are driven are called *followers;* but, as Lord Grimthorpe remarked, it seems absurd for the thing that is driven to be called a follower, since the horse is generally in front of the coachman.

The centre wheel drives a pinion on the third wheel, which will be to your extreme left as you look at the clock, and the third wheel, in its turn, drives the fourth wheel, which is in the centre of the frame directly above the arbor of the centre wheel. This fourth wheel turns once in a minute, and if you examine it carefully, you will see that its arbor projects through the frame in front, being longer than that of the third wheel. If the clock were provided with a second hand, that hand would be fastened to this projecting arbor.

The centre wheel has 48 teeth on its rim, and drives the pinion on the third wheel, which has six leaves. The third wheel itself has 45 teeth, and drives a six-leaved pinion on the arbor of the fourth wheel. Applying the rules given above, it will be clear that the third wheel turns once in $7\frac{1}{2}$ minutes.

Now we come to the most important part of the clock—namely, the escapement.

The Escapement. Examine your clock again, and you will notice that the fourth wheel drives a pinion attached to a very small wheel with peculiar teeth, and that these teeth are controlled by a little brass or steel piece of curved mechanism, which lets one tooth at a time escape. This wheel is called the *escape wheel*, and is commonly spoken of as the *'scape wheel.* The brass or steel arrangement which permits of the teeth passing is called the *pallets.* The name strictly applies only to the actual projections of steel or brass which intersect the wheel, but the one word will pass. The pallets, with a long brass lever attached, are fixed on the pallet arbor, between pivots, and the lever is swung backwards and forwards by the balance, or, to be more correct, the lever end passes and repasses a pin on the arbor, or "staff," as it is called, of the balance, imparting an impulse to it on each occasion. The impulse is derived from the pushing action of the teeth of the 'scape wheel on the faces of the pallets. In the clock we are considering the fourth wheel has 48 teeth on its rim, and drives a pinion of seven leaves on the 'scape wheel arbor. The 'scape wheel itself has 15 teeth, so the actual value of one turn of the 'scape wheel is $8\frac{3}{4}$ seconds, and one tooth, therefore, is equal to seven-twelfths of a second. Now, one complete swing of the balance lets one tooth escape, giving two ticks, one on the upward and one on the downward revolution; each tick, then, is equal to seven twenty-fourths of a second.

The pace, then, at which the balance, or pendulum, in larger clocks vibrates determines the number of teeth and leaves on the 'scape wheel, for if the pendulum beats a second at each tick, then the fourth wheel could be used as a 'scape wheel, provided it

had only 30 teeth round its edge, or if it had 60 teeth on the rim it would work with a pendulum beating half a second at a tick.

Taking to Pieces. We shall not deal minutely with the balance and its spring here, because it is only a magnified form of those we shall meet later on when we speak of watches and of larger clock escapements; suffice it to say that large and heavy balances swing to and fro more slowly than smaller and lighter ones. A suitable balance being selected, the strength of the balance spring will, within certain limits, determine the time of vibration of the balance, and therefore govern the speed with which the hands travel round the dial. By altering the effective length of the spring the timekeeper is regulated to go faster or slower.

Our business is to take the clock entirely to pieces and to verify the knowledge we have gained. Then we can clean it and put it together again. In addition to our tools, we shall now want a couple of soft brushes, costing about eightpence each—or two old toothbrushes will do for the experiment—a lump of chalk, or a crust of very dry bread, a number of match-sticks, a quantity of tissue paper, and a little good oil, preferably clock oil.

On the top of the clock you will find a small screw with a flattened head, which, you will see, serves to keep the balance in its place. Note this, and trace the balance spring to the point where it enters a stud and is pinned in with a small brass pin. With the point of your knife scratch the balance spring slightly on the far side from the portion that works, so that you may be able to replace it in the same position later; then withdraw the pin.

Next loose the flattened screw till the balance is just about to leave the sockets in which it works. Turn the balance carefully round till the balance spring is quite drawn out of the brass stud and from the regulator fork, then further loosen the screw and remove the entire balance with your tweezers, being very careful not to damage the little pin which plays against the forks of the lever. Lay this aside out of the dust.

The Wheels. Next examine the bearings of the pallet arbor, and in most of these clocks, if not in all, you will find that one end is held in a small brass cock, which enables one to regulate the exact depth which the pallets should intersect the wheel. Scratch a slight mark on the plate alongside this, so as to be able to replace it in position, then unscrew the screw, first holding the clock so that one of your fingers bears on the rim of the third wheel. The instant the pallet is clear of the 'scape wheel, the clock will begin to run down, and you must check it with your finger, being specially careful not to let the pallets drop into the clock, or the mechanism will be damaged.

When the clock has run down you can remove the four small nuts which screw on to the ends of the pillars separating the frames in this sort of clock, or in any other you can prise out the pins passing through the ends of the same pillars. The top plate will now lift off, and if you do this very carefully, you will not derange the wheels very much. Carefully note the position of each wheel, and then remove them in the following order; first the 'scape wheel, next the third wheel, then the fourth wheel, and then the great wheel, getting the lower pivot of the latter out of its hole before pulling the spring off the pillar to which its outer end is fixed. The centre wheel you need not remove, though that can be done easily by pressing out the pin above the star-shaped steel spring, and pulling the wheel and pinion off the arbor, leaving the arbor and the cannon pinion attached to the frame. In this class of clock you will not be able to remove these.

Cleaning. Examine the wheels one by one, wiping off all oil, brushing the teeth of the wheels, and the pivots on which the arbors turn. Unhook the mainspring from the great wheel by holding the spring in your left hand and turning the wheel in the opposite direction to that which would wind it up. You will then hear the hook unspring and the spring can be pulled off. In doing all this no force must be used. On the great wheel you will notice a little ratchet and click, which enable you to wind up the spring on the barrel with the key, but do not allow you to damage the remaining mechanism. As the barrel unwinds, the ratchet catches the click, and the great wheel is driven round, thus making the clock work.

Having cleaned off the greater portion of the oil with tissue paper, and brushed off the remainder, cleaning the brush from time to time by rubbing it across the lump of chalk or the dry crust of bread you can finish off each wheel, arbor, pinion, and ratchet by brushing with a clean brush, holding the work in tissue paper while you do so. Then place all the clean parts under cover—inverted tumblers do very well.

The plates must next be cleaned by sharpening matches and thoroughly cleaning out the holes in which the pivots work with the sharpened ends, till the wood comes out clean. The plates themselves can be wiped clean with paper. The spring, if very dirty, may be cleaned with a piece of paper wrapped round the blades of the tweezers.

Putting Together. Replace the centre wheel on the centre arbor, and pin it in by pressing down the spring and forcing in the pin, holding everything in paper. Now put the mainspring on the great wheel arbor, or barrel, and roll up the spring as well as you can, so as not to make it too bulky, and pass the looped end over the pillar, remembering that the spring must leave the pillar in the opposite direction to the motion of the hands of a watch. Dodge the arbor of the great wheel into its place, passing the rim of the great wheel under the centre wheel, so as to engage the pinion of the centre wheel. Next, put the fourth wheel in its place, putting in the long pivot first, and then get the third wheel into position, being careful not to strain anything, and remembering that its pinion engages with the teeth of the second wheel, and its teeth with the fourth wheel pinion. Next put in the 'scape wheel. Now all is ready for putting on the top plate. The longest arbor is that of the great wheel, and then that of the centre wheel. These must be passed through their holes, and the four pillars then just entered into place. With your tweezers lead the upper pivot of the third wheel into its place. Again lower the plate a little, and slip the end of the fourth wheel into its place, and the 'scape wheel will require only a slight touch to enable you to bring the plate home properly. The ends can then be fastened with pins or nuts.

Before going any further, press the great wheel round with your finger and see if all the wheels run sweetly. If they do, all is right; if not, you must take off, or loosen the plates, and see what is wrong. The slightest pressure should turn all the wheels freely. Next, for future guidance, notice that the teeth of the wheels and leaves of the pinions engage for about two thirds of their length. This is known as the "depth," and in very fine watchmaking, or after doing repairs, sometimes gives trouble.

The pallets are then put in, the little cock being brought to the mark you scratched on the plate, and if it is correct, when you give the spring a wind and lift the lever up and down with your tweezers, one tooth at a time should escape. At the same time the pallets should not go deeper into the teeth of the 'scape wheel than is necessary.

Take the balance and carefully pass the spring through the stud, but do not pin it till you see that the pin on the staff is in the notch of the lever when the pallets are at rest, and when the mark on the spring is in the same place as it was when you made it.

In replacing the balance spring do not forget to pass it through the regulator clip, for in taking it out it will have cleared itself automatically. Now tighten up the pin in the socket to hold the spring, and screw up the flattened nut so as just to give the balance the same play as it originally had. It should not shake when moved from side to side, though all the other wheels will shake perceptibly. If all is well, the clock, when wound up, should now go. If it beats for a bit, and then stops, see if the pallets intersect too deeply, and if so, very slightly loosen the cock screw and raise the pallet arbor the minutest fraction; but if the above directions have been carefully attended to, and the work tested in progress as indicated, the clock should tick regularly.

Finishing Touches. The minute wheel must next be put on the front, and then the hour wheel. All pivots should now be oiled by taking up the most minute drop of oil on a pin or piece of brass wire, and applying it to the holes in which they work. Over-oiling spoils many clocks. The bearings in which the balance runs may be oiled prior to replacing that part, though with neatness they can be oiled when all is together, though many of the best clockmakers are in favour of postponing oiling till the last possible moment, for fear of dust getting into the bearings and clogging the oil. In many clocks, however, you will be forced to oil several pivot holes before beginning to put the article together, and in all watches this is absolutely necessary, for the bearings could not be reached later.

The clock can now be replaced in its case by reversing the procedure used in removing it, and the first lesson in watch and clock making is ended. Practice will enable the beginner to take a clock completely to pieces and restore it to its original condition, with the exception of regulating, in a very short time.

From this lesson we have learnt that every clock or watch, of which we have chosen the commonest type, consists of a wheel which is turned by some power, and which in turn imparts motion to wheels showing the time; the train of wheels is further continued till a wheel is reached which, according to the beat of the pendulum, balance, or other regulating appliance, will turn with just sufficient rapidity to cause the time-telling wheels to fulfil their functions. We have also learnt a little manual dexterity, and have seen the principle upon which the teeth on wheels and pinions are calculated.

Pendulum Clocks. We now come to clocks operated by pendulums, such as we commonly see on the walls of our halls. Remember the little brass lever in your cheap clock, and how, by the revolving of the balance wheel, it appears to be moved backwards and forwards, though in reality the balance wheel is partially moved by it. Well, remove the brass lever, and imagine a piece of wire fixed at right angles to the pallet arbor, and hanging down from it towards the bottom of the clock. If this wire ends in a little fork, and a pendulum, with its rod turning on a pivot some little distance above the fork, be set swinging, then, if the rod pass between the jaws of the fork in such a way that as it swings it moves it from side to side, and receives the same impulse as the balance wheel did, we have the elements of a simple pendulum clock, for, once the pendulum is started swinging at each stroke, it will shift the pallets, allowing a tooth to escape, and at the same time it will receive a tiny blow which will just suffice to make it continue swinging regularly.

Swinging Movement. In such a simple arrangement, which practically obtains in most of our house clocks, the wire running down from the pallet arbor is called the *crutch*, and the fork is the *fork*. The pendulum is generally suspended by a bar which, at the upper end, terminates in a fine piece of steel spring, known as the *spring*, which is fastened between two pieces of brass at the top of the rod, known as the *lower chops*, and again passes between two more pieces of brass, called the *upper chops*, which in turn are attached to a brass block, or lump, called the *pendulum cock*. In cheap American pendulum clocks the rod is simply a wire which is flattened out and tempered at its upper end to form the spring, which is fastened between the upper chops.

The principle upon which pendulums work, omitting the higher mathematics necessary to make the calculations, is that at the latitude of London, a bob at the end of a string 39·14 in. in length will swing once in a second. By mathematics, the length of a pendulum to oscillate in any given time can be calculated; but as the process is intricate, we give the following lengths as those most usually found:

To swing once in one second, 39·14 in.

To swing once in three-quarter second, 22 in.

To swing once in two-thirds second, 17·4 in.

To swing once in half second, 9·78 in.

These lengths are measured from the edge of the upper chops to the centre of the weight.

In adjusting a new pendulum to a clock the points to be observed are that the edges of the chops, where they meet the spring, are perfectly square, for if they are curved they will cause the pendulum to twist as well as to swing. Then, the pendulum *must* vibrate in a plane exactly at right angles to the pallet arbor, and the pendulum must be suspended so that the bend of the spring is exactly opposite the pivot of the pallet arbor.

The weights of the pendulum itself may be made of many substances, but in the clocks which we are likely to meet with at first they will be of either brass or lead. In very high-class clocks the pendulum weight often consists of a glass bottle filled with mercury, or of a series of brass and zinc bars. These are forms of compensating pendulums, designed by the very scientific horologists, like the late Lord Grimthorpe, who designed the great clock at the Houses of Parliament, and they should not be tampered with by the ordinary clockmaker, for much mathematical knowledge is required before their adjustment can be understood.

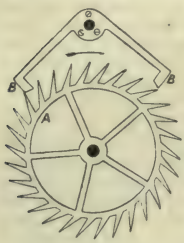
Escapements. The two clock escapements which are most generally to be found in common house clocks are the *anchor recoil escapement* and the *dead beat escapement*. These can be easily recognised by the shape of the pallets, and much waste of words will be saved if our readers will compare the two drawings given on the next page.

In the anchor escapement it will be noticed that the teeth of the wheel are pointed, with straight sides, while the pallet itself has a different shaped tooth, or shape, on each side, that on the side

from which the wheel is coming being slightly curved on its outer side and flat on its inner surface, while in the other pallet face the converse obtains, the curved surface being on the inside, and the flat edge on the side to which the wheel is going. This is called a *recoil escapement*, because when the left hand pallet has just escaped, the pendulum still swings a little further to the left and the face of the pallet on the right-hand side drives the wheel a little backwards again, as will be readily understood from the drawing [2]. Then when the pendulum turns to swing back again, this little recoil gives it an impulse, by giving the right-hand pallet face a little shove, and so sets the pendulum off again. Then when the swing to the right is accomplished the same thing takes place again. The above is not necessary in *theory*, because if all friction and the resistance to the air were eliminated the pendulum would swing continuously; but in practice the clock would stop in a short time were no impulse given.

2. ANCHOR RECOIL ESCAPEMENT

Dead-beat Escapement. The dead-beat escapement [3] is much more difficult to explain, and we are indebted to the admirable work of Lord Grimthorpe for the following simplest description, though we are not quoting verbatim. The pallets are of the anchor form in appearance. From the centre of the pallet arbor a distance is taken to the point where the point of one tooth would just touch the left-hand, or receiving pallet. This forms the radius of a circle, and that circle gives the form of the outer face of the receiving pallet. A similar circle is made from the centre of the arbor but of a radius less by the thickness of the pallet tooth. This circle, when described, gives the receiving part of the inside face of the right-hand pallet. These curves give the exact shape of face which will prevent the wheel from turning backwards as the pallet tooth is driven in by the swing of the pendulum. The impulse face is made on the point of the pallets, and consists of a flat surface from the receiving point of each to the point of departure. The action is as follows: When a tooth escapes from the left-hand pallet it permits another to touch the right-hand pallet. As the pendulum continues its swing the tooth point travels up the hollow curve, and the wheel does not move. On the swing of the pendulum, the pallet moves, drawing away from the tooth till the corner is reached, when the force of the 'scape wheel pushes the tooth along the impulse face, giving a shove to the pendulum, and the moment the tooth leaves one pallet the other pallet engages at the locking face, the tooth sliding up the slight curve. On its return another impulse is given by the tooth. The teeth of the 'scape wheel are dead flat on the forward side, and deviate a little from radial lines, so that their tips only make contact with the curved locking faces of the pallets.



3. DEAD-BEAT OR "GRAHAM" ESCAPEMENT
A. Escape Wheel
B. Pallets

In this form of escapement much friction is saved, since there is no retrograde movement of the 'scape wheel, and of the other wheels of the train, and also there is much less jar.

The more elaborate escapements used in high-class turret clocks form material for the study of advanced scientists, and so need not be included here. For a description of them Lord Grimthorpe's work on clocks and watches may be consulted.

Weight Clocks. Only small pendulum clocks have their main power imparted by a spring. In weight clocks a cord passes round the barrel of the great wheel, to which the weight is attached. Obviously the tendency of this weight is to run down, and so to turn the great wheel, thus doing the work which the spring did in the small clock which we considered first. The weights may be fastened by a single string, but that gives a tendency to twist, and it is better for one end of the string to be attached to the barrel, the other to pass through a pulley on the top of the weight, and then be fastened to the seat board of the clock or to some point in the frame. By this means there is another gain, for the weight will have to fall through only half the distance.

Eight-day Regulators. Having now gained some insight into the mechanism of ordinary clocks we are in a position to begin a small job; and to gain experience let us suppose that we have received an ordinary eight-day clock to overhaul and to execute any necessary repairs. Besides our former tools we shall require a small bench vice, some fine files, screw-drivers of various sizes, a pack of cards fastened in the middle to form a sort of square cardboard brush, a little hammer, and possibly a pair of turns and some gravers, which we shall describe when we have to use them. We may also need some drills, which can be bought for very little, and with the turns we shall have a number of ferrules, drillstocks, and centres.

The first thing to do is to examine the clock before we take it out of the case, for its stopping may be due to the hands catching, to the weight cords getting entangled, or to some other visible cause. When we find that we cannot explain the accident by any immediately remedial cause we take the movement out of the case. First take off the weights and the pendulum. In taking off the latter you will have to use your own judgment, carefully examining it to see how it is fastened. In many clocks the pendulum is suspended from the back of the case entirely free from the movement, and in that case it may be left where it is. In others you can get at it from the back, and remove it from the sustaining cock. Again, you may not be able to do that, and may have to remove the weight, and take out movement and rod together, though this should be avoided as far as possible, since great trouble will be caused in regulating the clock later on. However, if it is imperative, and the pendulum weight is held on a fine screw, turn the screw half a turn down, then make a little mark close to the edge of the upper side of the weight so as to know just how to replace the bob, and then continue to take off the weight. Next remove the *bell*, *bell stud*, and *screw* for same.

Removing the Dial. Place the clock, dial downwards, on the board and take out the screws which fix it to the seat board. Then take out the cock screws and remove the pallets, but remember to replace the cock in position, for that will prevent you from scratching the back plate when you turn the clock over.

In this class of clock the hands are secured by tiny pins, and these you take off with pliers; take off the hands, and then remove the dial by unpinning it. The holding pins vary in position but will easily be found. Once the dial is free you will get a good view of the mechanism, and you will notice that instead of the simple motion which we met with in the cheap clock, there are several wheels, and perhaps a ratchet, all on the front plate of the clock. Most of these are connected with the striking movement.

Striking Movement. If we examine the inside of our clock before we go any further we shall see that there are two distinct trains of wheels inside. First there is the going train, with which we are familiar, and then there is another train consisting of a barrel with weight and great wheel attached to it, working on a wheel and pinion, known as the *pin-wheel,* and this works on another pinion and wheel, known as the *gathering pallet* wheel, which works on the warning-wheel, and lastly, a flat pair of plates with a pinion on the arbor, called the *fly and pinion.* In front of the clock we shall see on the top of the hour wheel a curious piece of brass which is called the *snail,* and its name will readily enable you to distinguish it. The snail is divided into twelve steps, and is adjusted so that the fall of each step allows a lever, called the *rack tail,* which rests upon the steps, to fall just sufficiently far to liberate a number of teeth on the rack equal to the hour to be struck. A little piece of brass gathers up these teeth, and then stops the running of the striking train by catching against a pin. This causes the whirring known as the *warning.* The rack is then caught by the rack hook, which holds them till it is raised by the detent, which, as you will see, is lifted by a lever displaced hourly by a pin on the minute wheel. A few minutes' examination will make this perfectly clear.

These levers are held on studs by little pins, which you must withdraw with your pliers. Then remove the motion work and all on the face of the clock, first making a rough sketch, if you cannot hold the positions in your memory.

Dismounting. The front plate of these clocks is held by pins passing through the pillars, and these must be extracted and placed so that the right pin may be returned to the right hole later. Now take out the parts, as we have done before, and clean the clock, using rottenstone and oil first, then whiting, and, lastly, fine-powdered chalk. Any rust on the steelwork must be removed with flour, emery, and oil applied with a piece of wood cut to fit the part. The card brush is useful for cleaning the teeth of the wheels.

Next brush the plates carefully, brushing lengthways of the plate, and only in one direction, so that any marks which may be made will not spoil the appearance of the plates. Finish off in the same manner as the wheels. Wooden pegs will serve to clean out the holes in the plates, though most clockmakers use strips of leather.

Examining. All being clean, get ready to put the works together again, but, not to spoil the actual pins which hold the frames on the pillars, make a set of examining pins out of steel wire, by turning a loop at the end of the wire, and then on the bench vice tapering them off to a neat point. We shall not give ordinary directions for metal-working, because they will be found in the articles on mechanical engineering in these volumes. Be careful to finish your pins neatly, for fear of scratching the pin-holes.

Before putting the clock together, examine each wheel carefully prior to putting it into its place. See that all the teeth are uninjured, and if any are bent, you must restore them to their place with the pliers. If any wheel is loose on its arbor, it must be carefully riveted tight with a half-round punch and a light hammer. This can be done in the vice, but it is better to have a steel stake with a hole in it just large enough to take the arbor or pinion, and allow a good bearing for the collet. Then try the pallets and crutch, and see that they, too, are tight on their arbors.

Testing the Movement. Now put the clock together, fastening it with the examining pins. See that the wheels have just enough play in their holes to move slightly, so as to clear the shoulders of the pivots, but not any more. This is called the *end shake.* Try the pivot holes by spinning the wheels in them, when they should not wobble in the slightest, and yet should run perfectly free and spin for some time.

The depth of the gearing must next claim our attention. By this is meant whether the teeth just engage sufficiently in the pinion leaves. The easiest way of doing this is to press the wheel round in one direction and the pinion in the other, just allowing the force on the wheel to overcome that on the pinion. If the depth is too deep or too shallow, the teeth will lock or catch instead of running smoothly. If the depth is wrong, a new pivot hole will have to be made, as will be explained later. Examine the pivots, and any that are too small and worn uneven must be "run" in the turns till quite smooth and circular, and a new hole made to fit them.

All the wheels having been examined and put into place, the escapement will next claim attention. The pattern will probably be the recoil given above. See that the faces of the pallets are perfectly smooth, and, if not, file them up carefully, and burnish them to shape. See that the drop on to each pallet is equal, and the clearance of the free pallet should be just sufficient to allow the tooth to escape. The backs of the pallets should not scrape on the wheel teeth. One authority gives as a good rule for eight-day regulators that the end of the crutch should move ½ in. from drop to drop of the wheel teeth.

Dead-beat escapements are very hard to repair if they are much worn, though it must be said that they do not wear as much as the recoil pattern does. If slightly worn they may be filed and burnished up to shape, and will last for years, but if more damaged, new pallets will have to be cut, using the old one as a pattern. This will not be difficult for anyone accustomed to metal-work, but, later, full directions will be given.

Replacing Pendulum. Now look at the crutch, and see that it just holds the pendulum freely without allowing any end shake. If it is rough inside it must be polished and slightly lubricated. Now see that the slit in the cock is exactly perpendicular, and that the pendulum spring fits it exactly. Now put all into place, see that the pendulum swings an equal distance from each side of the middle line, look down the clock from the top to make sure that all is going smoothly, and then, with your oiler, apply just the tiniest drop of oil to every part where friction can occur. Many say that no oil should be put on the pallet faces, but the highest authority declares that a most minute quantity greatly improves the working of the clock.

Before paying any attention to the striking mechanism of the clock, you should see that the pallets are removed again, and the crutch, or else

you may damage your escapement while experimenting with the other parts. But to save the back from being scratched, and to raise the back plate a little, replace the cock after liberating the pallets.

Striking Mechanism. The next thing to look to is the striking mechanism. This is occasionally damaged, though the actual train within the frame is seldom in need of repairs. First, we must see that the acting face of the hammer tail is in proper relation to the pins of the pin wheel—that is to say, it should be a tiny fraction of an inch above the centre line of the pin wheel. The length of the tail should be such as will allow it to drop from the pins, and when at rest it should be about the distance of two teeth from the next pin.

The *rack* is the part of the mechanism which regulates the number of strokes to be given to the bell. Its first tooth should be a little longer than the others, so that the other teeth will not grate on the rack catch, and cause an unpleasant noise, as well as wear out the teeth. The tumbler, or gathering pallet, is really what is called a *clutch* in mechanics, and it may be worn, in which case it will have to be filed up to shape, or a new one inserted in its place. It is not a difficult piece to make if its functions be remembered. It has been suggested that the figure 6 is a good model to take in making a new gathering pallet. The tumbler must lift a little more than one tooth, and let the rack fall back again a little, or else the clock may take to striking irregularly. The acting faces must be quite smooth and well polished. If the teeth of the rack are found to be a little too low from the gathering pallet, and require raising slightly, then, if you place the rack on a smooth anvil and tap the stem with a light hammer, the stem will be slightly stretched, and the entire rack will thus be raised. The rack catch may be worn, but as the tooth of it is always much wider than the teeth of the rack itself, it will be worn only in one place. Its shape can thus be known, and the catch, if not too much worn, filed to a smaller but still efficient shape. After this operation it may be necessary to stretch the rack, though that is not likely to be the case.

Replacing Train. In putting the inside work belonging to the striking train into place, some of the wheels have to bear arbitrary positions in relation to others. These are the pin wheel and gathering pallet pinion, and the warning wheel and the detent stop.

The wheels of the entire mechanism of a striking clock should be placed in the frame in the following order, for to get the striking train in after you have mounted the going train would be very difficult—centre wheel, third wheel, both great wheels, hammer, pin wheel, escape wheel, gathering pallet wheel, warning wheel, and, lastly, the fly.

Having got them all roughly in their places, put on the top plate with examining pins, and temporarily mount the rack, rack spring, rack hook, and gathering pallet. Now see that the rack hook has gathered up all but one tooth of the rack, and move the pin wheel slowly round till the hammer tail just drops off. At that instant the tail of the gathering pallet should have about a ¼ in. between it and the pin in the rack, which stops striking. If there is more than this, or if the hammer tail is resting on a pin, then the top plate must be raised a little, and the pin wheel turned a tooth further on in the pinion until the required position is obtained.

The run of the warning wheel must be adjusted. Put on the lifter, and gradually lift it till the rack hook liberates the train and warns. The warning pin should run just half a circle before it touches the detent top, so at the moment of release should be diametrically opposite to that stop. Also you must see that the warning pin catches fairly on the detent stop.

This train now being in as good order as the going train, we can remove the rack, take out the examining pins, and pin up finally with sound pins, replacing any which may look at all battered.

The Cannon Pinion. The cannon pinion spring and cannon pinion are now put on the minute wheel, which must be in such a position that the pin on it drops the lifter at the instant that the minute hand is upright. To test this put the minute hand on the square of the cannon pinion and then place the minute wheel in proper position. Take off the minute hand, and put on the hour hand, again seeing that the hour hand is in its proper position when the snail allows the rack end to fall and the clock to strike. This seems trivial, but often the beginner forgets that unless he takes these precautions he may have to take the clock to pieces again very soon. The rack should next be replaced, and all the striking mechanism carefully looked at again before the dial and hands are pinned on.

Turn the clock round and put on the pallets, screw on the seat board, and oil the pulleys from which the weights hang. The movement can then be put into the case, seeing that the dial is upright. Hang on the weights and wind them up carefully, and, finally, put on the pendulum. If the pendulum is now gently started the clock should begin to go.

But the clock will not go properly unless it is "in beat," and to test this when the pendulum starts from rest it should have to be moved as far to the right for the first tick as it has to the left to get the second tick, measuring from the centre line. If the clock is in beat, and so the ticks are regular, no adjustment is necessary, but if the right-hand beat of the pendulum comes too quick, then the crutch requires to be bent a little to the right, while if the left-hand tick is heard before the pendulum has had its proper swing, the bottom of the crutch must be bent towards the left. Very little bending will make a great deal of difference, so great delicacy must be exercised in this operation.

The clock should now go well, but must be regulated. If it is too fast, the pendulum bob must be lowered a very little, and if too slow the bob must be raised. The amounts necessary to make a great deal of alteration in the timekeeping are very slight indeed.

Repairs. Undoubtedly repairing is the chief work of the modern clock and watch maker, for if he wishes to make a new clock he buys the parts in the rough from wholesale manufacturers, and finishes them up himself. Consequently, if the young clockmaker learns how to do the ordinary repairs, he will have learnt all that he will require, save for the designing of the plates, to enable him to construct a clock himself, should he ever be called upon to do so.

Pin-making. This is the first job that the budding clockmaker has to learn, and this he must become proficient at, for until he can make a pin decently he has not learnt how to use his file and burnishers, nor has he acquired the delicacy of touch which is essential to success in this trade.

At this stage we shall assume that we have access to an ordinary small clockmaker's bench, with the few tools which are generally to be found thereon, for when the embryo watchmaker has practised the foregoing lessons he will know whether he has found the calling which he wishes to pursue.

Clock Pillar Pins. To make a pin to fit a clock pillar, take a piece of hard wood about three-quarters of an inch square in section, and an inch and a half long. See that the faces are quite smooth. Secure it in the bench vice firmly, and with an ordinary graver cut the surface, and parallel with the jaws of the vice a series of four or five longitudinal grooves of varying depths, the deepest being $\frac{5}{16}$ in., and the others running down to a tiny groove. The section of these grooves is V-shaped.

Now take a pin vice, various patterns of which will be found on every bench, such being simply small hand vices arranged to hold fine wire either by means of a clamping screw or a circular screw like a lathe chuck. Into the vice put a piece of iron wire, stouter than the hole you wish to fit. Part of the wire will run through the handle of the vice, and about an inch should project beyond the jaws. Take the vice in your left hand and lay the wire in the deepest groove. With a file in your right hand hold the wire in the groove. Now twirl the vice with your fingers, so as to turn the wire towards you, and as it turns push the file away from you. Then reverse the motion, always making the file move the opposite way to the wire. Keep moving the file so as to get as fair a taper as you can in the deepest groove. Then take a finer file and shift the wire to the next groove. This will complete the taper very nearly, but will leave some file-marks on the pin, which make it look unsightly, so take a still shallower groove and a flat burnisher in place of the file and again twirl the pin till it is perfectly smooth and polished.

Push the pin home in the pillar which it is to fit, and with a graver mark each side the distance it should stand out to give a firm hold and to look well. Then remove the pin again, and with a graver, working against the twirling wire in a groove, deepen the nick at the thin end. Into the deep ring thus made put the edge of the burnisher, and with a few twirls the thin end of the pin will be cut off. Now advance the point a little over the next end of the filing-block and finish off the point with a fine file and the burnisher, so as to round it neatly. Deepen the other nick in the same way with graver and burnisher till it nearly cuts off the pin. Insert the pin in the pillar, and give a slight bend when it is well home, and the pin is finished and in its place, snapping off neatly at the thick end.

Repairing Pivots. If a pivot is worn unevenly, or badly cut, but is thick enough to be made into a finer pivot this can be easily done by the process known as *running a pivot*,

To do this the turns are placed in the vice. The turns are really a miniature lathe, having the motive power imparted to the object by means of a bow having a gut or horsehair cord working round a ferrule, or tiny wheel. The cord of the bow is passed once round the ferrule in such a direction that the down stroke of the bow makes the ferrule revolve towards you, and the up stroke away from you. In filing with the turns both strokes are used; but in graving with a cutting tool only the down stroke is employed, the graver being lifted while the up stroke is made. The turns have a variety of centres, suited for different kinds of work, those in which a point runs being called *female centres*, those with points against which a flat piece or a tiny spot runs being *dead centres*, and those with grooves which support a piece of work being *running centres*. A good watch or clock maker will have a variety of centres, many made by himself.

Now take the defective wheel and arbor. On the sound end fix a screw ferrule not far from the end. A screw ferrule is one which can be clamped on to a piece of metal, holding it true in its centre. Place a female centre in one end of the turns, and a running centre in the other. Put the point of the sound pivot in the female centre and adjust the position of the running centre so that its groove receives the imperfect pivot and allows it to have a good bearing. Put the gut of the bow round the ferrule, and, placing the plain edge of a very fine file against the shoulder of the defective pivot, file it down as it turns, always moving the file in a direction contrary to that in which the arbor and pivot are revolving. When the pivot is filed quite straight and smooth, burnish with a flat, plain burnisher and the fresh pivot is made. It will require a fresh hole to run in; presently we shall learn how to make this.

Replacing a Pivot. To replace a pivot which has been broken off, first file the broken end of the arbor quite flat. Then put on a screw ferrule, as before, on the sound end. In place of the running centre in the turns place a drill stock centre, which is a true centre made to hold a fine drill, with its point exactly opposite the other centre. With a graver mark the exact centre of the filed arbor end. Place the good pivot in the female centre, and the bow round the ferrule. Press the sliding portion of the turns, which is carrying the drill centre, so that the point of the drill exactly fits the tiny mark on the arbor made by the graver. Hold the sliding part with the hand so that the drill presses close up to the arbor and revolves with the bow. By this means a hole will be drilled straight up the centre of the arbor, true in the middle.

Clean out the chips from the hole. Next draw-file a piece of tempered steel wire to fit the hole exactly, and drive it in tightly; then cut off the length required. Point this new piece so that the wheel and both pivots run true between two female turns. Now turn the new pivot down with a graver, just as in metal turning, till it is nearly the right size, after which run it in a running centre. Burnish it, and round off the end neatly in the rounding up centre, which is one which supports the pinion but enables the worker to get at the extreme end of it. A new pivot may be fitted to any of the pinions in the same manner, but most especial care must be taken to get the exact centre of the pinion before drilling the hole, or else the wheel will be ruined. Where a lathe is to be had, a special chuck will enable you to centre, in the ordinary way, but where such is not obtainable a bell punch is a most useful tool for fairly large work. Smaller pinions must be centred by experiment, shifting the position of the drill point till the true centre is found, and then drilling as before. If the workman has to use the turns for drilling a split collet, it will hold the pinion better than a screw ferrule.

Drilling. When it is thought advisable for the drill to turn, instead of the work which is being drilled, drill stocks, fitted with ferrules, can be used. Some of these work in the turns, and others are used by pressing the pointed end against a depression at the end of the jaws of the bench vice, and pressing the work to be drilled against the other end, while the tool is rapidly rotated. The use of the drill in this manner requires considerable practice before proficiency is attained.

In drilling arbors to take new pivots great care must be taken not to split the arbor, and the same care must be exercised in driving in the new piece of steel, which should be gauged so that a light tap

with a hammer is sufficient to drive it tight home, and it should hold by its own friction. If the worker has an accident, and splits an arbor, the only way to repair it effectively is by putting a ring or collet over the split part of the arbor. Sometimes this is not possible, and then the new pivot must be soldered in, a most objectionable practice. However, if you have to solder one in remember to dip the soldered part into oil before it cools, or else you will be sure to have rust breaking out later, and spoiling your work.

Defective Pinions. If the leaves of the pinions are badly worn or cut it is bad practice to file out the marks, because that would make the leaves too thin. The best plan is to turn a small quantity off the shoulder of one of the pivots, thus making it sink further through the plate, and then put a raised bush on the plate on the opposite side to receive the other pivot. This will have the effect of shifting the bearing points on the pinions both of the wheel you are operating on and on the one which its wheel drives.

A Broken Pinion Leaf. If one of the leaves of a pinion is smashed, the only good method is to make a new pinion, and as this will frequently have to be done when fitting up a new clock, we shall take this method first. Pinions are generally bought in the form of pinion wire, which is steel wire drawn through plates which have the effect of cutting out leaves of varying numbers, from six to sixteen leaves. This pinion wire is sold in one foot lengths.

First of all cut off as much as you will require for the new pinion, arbor, and pivots, and a little to spare. Then, with a smooth file finish off the leaves, and see that the pinion is quite straight. This is done by placing the pinion between the turns, revolving it, and passing a piece of chalk along the side nearest to you so as just to touch the pinion. The bulge of the bent side will be marked, and the hollows unmarked. Lay the pinion, if much out of truth, on a smooth anvil with the marked side down, and tap the hollow side with a light hammer very gently till the pinion is nearly true. At this stage the pinion need not be quite true, for after it has been worked it will have to be trued again.

Now harden the pinion as follows. Tie a piece of soft iron wire round one end securely. Cover the leaves of the pinion with soap, fairly thickly. Have a good clear fire and a jar of water ready. Put the soaped pinion into the fire till it is all red, selecting a place where no coals can fall on it, and bend it when red. When all red pull it out with the wire and plunge it vertically into the jar of water. If you plunge it in obliquely, you will probably bend it. The soap is to prevent the leaves from being burnt before the body of the pinion is red hot.

Tempering. When the pinion is cool it must be tempered. Make a U-shaped piece of wire, with a loop at each end, to hold the ends of the pinion. Hold the end of the loop and pass the pinion through the flame of a Bunsen burner till it is warm. Now cover it with tallow or oil, the warmth making either run well all over it. Again pass it through the flame backwards and forwards and lengthways till the oil or tallow takes fire. Immediately blow out the flame, and let the pinion cool a little. Then give it another coat of oil, and again set it on fire in the same way, and blow it out. This operation is known as *blazing*. Under no circumstances must the tallow be allowed to burn itself out, or the temper would be too soft.

Again true the pinion as before, this time bringing it to perfection, using a narrow steel stake as well as the flat of the anvil to ensure perfection. When the pinion runs true in the turns we can proceed to polish the pinion heads and leaves. Make a few wedge-shaped pieces of wood, about six inches long and three broad, and make a mixture of emery and oil. Dip one of the pieces of wood into the emery mixture, and rub the bottom of the pinion leaves with this mixture, taking each hollow in turn, and supporting the pinion on a piece of cork. When all the bottoms are well polished take another piece of wood with a groove cut in it to fit the top of the leaves, and with this polish the tops of the leaves till bright. Now clean off all the emery, and wipe the pinions quite dry. Then polish with crocus powder, used on a clean wedge and groove.

Making New Arbor. Mark off the portion of the pinion which is to be used in the clock (or watch, for the operation is the same) and then place the pinion wire in the turns, and turn down the leaves off the portions which are to form the arbor until the proper size is nearly reached. Solder on the collets on which the wheels, or wheel, is to fit, and turn them down smooth; then put on the wheel and rivet it neatly. Run up the wheel with a file, and then finish off the arbor with a smooth file and a burnisher.

The pinion head, or heads, as the case may be, next have to be faced up neatly, and this is done with two pieces of thick sheet iron, with holes bored in the centre a little larger than the pinion arbor. The best size for these is an inch square. Each side of the *facer*, as these iron plates are called, is filed up flat with a rough file, which leaves some small marks upon it. A little emery and oil is applied to the facer, and the arbor passed though the hole. Then the pinion is placed in the turns and rotated moderately rapidly while the face is pressed lightly against the head of the pinion which is to be polished. Every now and then you will have to file your facer again, because the tempered pinion steel will rapidly eat into it, and make it uneven. When the heads are thoroughly flat, you can finish them off with a clean facer and a little crocus mixed with oil. The wheel is next polished with a flat iron polisher, care being taken not to press too hard upon it, and the wheel being examined to see first that all the teeth are of the right shape. Any that are not quite right, whether the wheel be old or new, must be rounded properly with a topping file, which is a small file, cut on its flat face, and smooth on the other side, which is half round.

Finishing Off. The final touches are now given to the arbors by polishing them with a flat iron polisher charged with emery and oil, and then polishing brightly with crocus and oil applied on two pieces of wood between which the pinion revolves rapidly.

All the body of the new pinion, with its wheel attached, being now finished, mark off the exact length required and turn and run the pivots in the manner already described. When the new pivot is filed down there will be a slight burr on the edge of the shoulder; this should be removed with a graver before polishing, leaving a tiny chamfer.

Your first practice pivot, pinion, and arbors will teach you a lot in the manipulation of clockmaking tools, but you must not expect it to be workable, for only experience can make a skilled clockmaker; however, you will find that the second attempt will be more than twice as good as the first, and after a time you will acquire great precision.

Continued

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CLUBS, BOARDING-HOUSES & HOTELS

Catering for and Management of Clubs. The Way to Make a Boarding-house Pay. Seaside Apartments. Hostels for Women. Catering in Big Hotels

By A. B. BARNARD

CATERING for private clubs resembles that of hotel catering, but a few details of gentlemen's and ladies' clubs are given here.

Gentlemen's Clubs. The former, gentlemen's clubs, vary in the limitation of membership, the better class having a fixed membership, sometimes 1,500 or 2,000. The subscription for town members ranges from £7 to £10 10s. with an entrance fee of 10 guineas, sometimes more. There is a lower fee for country and colonial members—from £1 to £5, with, of course, an entrance fee. The number of luncheons varies from 60 to 100 daily, at a reasonable charge à la carte for four courses, dinner including six courses. The rental of clubhouses is high, but is generally covered by the subscriptions. Sleeping accommodation is provided at most clubs at a moderate charge of 5s. or 6s. per night. In general a large staff is required, the duties being heavy some days and light others. It includes the secretary, chief steward, head waiter, wine butler, cashier, valet, waiters, hall porter, night porter, house porter, pages, platemen, and maids. The wages for the chef run from £4 a week to £6, waiters get 14s. to £1 a week, and maids £14 to £18 a year and laundry, augmented in each case by the Christmas-box fund. Club wages are considered very good, though the working hours are long. A fortnight's holiday is allowed to those who have been a year on the staff. Loss may occur on a month's catering, for which the gains of another month compensate; much depends on the carving, some carvers being more economical than others. In most clubs 1s. a head is allowed per day for each member of the staff. The chef daily makes a list of his requirements, and orders his goods, the steward checking the weekly accounts. Meat and vegetables are obtained from local tradesmen, with whom special arrangements are made. They usually call twice a day for orders, and possess the advantage of serving better and being near at hand. It is usual to give away the broken food. Cold storage is used for perishable provisions, but no large quantities are stored, except in the case of dry goods.

The staff has its own hall, and the heads their own private sitting-room and bed-room. For the members' use there are a dining-room, smoking-rooms, reading-rooms, library, card-rooms, billiard-room, strangers dining-room, and lounge. From the large kitchen a lift passes up to a room off the dining-room, where joints are kept hot, and covers descend to the dishes from the ceiling. In most clubs the staff at Christmas has a ball, paid for partly by the club and partly by the staff.

Ladies' Clubs. An up-to-date ladies' club of 1,000 members, with a guinea subscription, is located in a spacious town house, the large rooms of which have been cleverly cut up and most daintily and luxuriously furnished as coffee-room, drawing-room, dining-room, silence-room, cloak-room, and smoking-room. The kitchens are at the top of the house, and have gas stoves. The charges for meals are: Breakfast, 1s. 6d.; dinner, 2s. 6d. to 3s. 6d.; supper, 1s. 6d. Four of the staff are in the kitchen (the chef and three others), three in the still-room. There are also six waitresses in the busy season, and five in the quiet season, beginning work at 8.30. Their wages run from £14 to £16; the girls get a fortnight's holiday and one half-day off a week.

Boarding-houses. In large inland towns and seaside resorts there is a steady demand for boarding-houses. That they often turn out financial failures is usually due to want of good management. The proprietor needs certain distinctive qualifications for the post, and here the personal equation counts for much. Houses are filled and kept full through the establishment of friendly relations between landlady and boarders. The former should be capable, efficient, tactful, kind-hearted, amiable, just, dignified in bearing, firm, diplomatic, a bureau of information, and able to show a smiling face to the world. Independent aids to success are:

1. Suitability of the house in size and situation.
2. Attractive appearance of the place inside and out, involving cleanliness, neatness, and artistic furnishing, good beds being an important item.
3. Neat, dapper, willing servants.
4. Appetising meals, varied from day to day, taken preferably at small tables.
5. Regular weekly payments by the boarders.

It is not a bad idea to make a plan of the house, and write in the space of each room the rental it should yield to cover expenses of rent, fire, light, service and furniture. When the cost of table is added, the total expenses of upkeep are obtained.

The following items are supplied by the manageress of a London boarding-house in the West End, containing 33 rooms: Rent, £200; taxes, £70; gas, £30; coals, £25; wages, £120; housekeeping, £650—total, £1,095. Average receipts for the year—£1,300, leaving a margin of £205 profit. Terms per week for boarders, with lunch, £1 10s.; without lunch, £1 5s. It is hardly possible to provide full board for less than 25s. a week, or two meals a day and full board on Sundays for less than one guinea.

A small, unpretentious boarding-house at Boscombe gives the following particulars: Rent, £80; taxes, light, coal, £40; wages, £30; housekeeping, £230—total outlay, £380. This should accommodate eight boarders, each paying 25s. per week—perhaps 30s. for large single bedrooms, but averaging 25s. for 44 out of the 52 weeks. Allowing for slack seasons, the receipts would average £440 per annum, thus yielding the small yearly profit of £60.

Apartments and The Hostel. Some people prefer a compromise between a boarding-house and lodgings. During holiday time materfamilias dislikes wasting the golden hours in shops, and when the landlady is reliable prefers to transfer ordering from tradesmen to one who knows the ropes, and does not suffer from exorbitant charges. Orders and hours for meals are entered every morning in a book, and accounts settled weekly.

Large profits may be made by enterprising landladies who know how to satisfy the tastes of certain wealthy clients. One at Eastbourne lets two suites of rooms and provides board at £22 to 25 guineas a week for the two. Her rent is £150 per

annum, and she is able to keep herself and four servants on the food left over.

One of the features of modern city life is the establishment of hostels and residential clubs for women employed in various ways. The expense of living in such a community is comparatively small, and the advantages are many. A girl earning 25s. to 30s. a week pays 15s. or more per week, but of course for such a moderate charge the affair can only be made profitable if conducted on a large scale. There is a great and daily increasing demand for good hostels for London's army of educated women workers. That the problem of housing these is one of vital importance every thoughtful person will admit.

Catering for a Yachting Cruise. In provisioning a yacht one encounters t e difficulty of supplying a vessel which may at any time, through stress of weather, be prevented from approaching land. Thus two important requisites, water and milk, may run short. Certain catering firms undertake to provision a yacht for either a short or long cruise, arranging to take back surplus stores at four-fifths of the original cost.

Items indispensable to a yachting cruise include various forms of tinned provisions—meat, fish, poultry, and game. Vegetables and fruits may be tinned or bottled, and jam is always appreciated. In the case of houseboats and wherries on the Broads the dearth of fresh meat, fish, and vegetables is less marked, though even there one hears of boating parties getting into difficulties over catering. Then, even when meat or poultry is obtained, it is difficult to keep it sweet in hot weather in the limited store space afforded by a houseboat or wherry. Insect pests, owing to the presence of water, prove especially tiresome. When coal is stored on board, the plan of wrapping the joint in a cloth and packing it in the coal is recommended. Condy's Fluid and vinegar are, of course, useful adjuncts.

A lady, whose catering during a fortnight for a party of eight in a wherry on the Broads afforded complete satisfaction, gives the following particulars and advice: "The total cost per head for food during the cruise amounted to £1 18s. 6d. This included the share of board-wages for two men in charge of the wherry, but not, of course, the hire of the boat. The provisions taken included a cooked ham and a large piece of pressed beef. A box of groceries (tea, sugar, a jar of pickles, condiments, tinned meats, fruits, and soup) should be sent from London to the centre of the Broads from which the start is made. Biscuits prove useful when bread runs short. Milk can usually be obtained from a farm near one's anchorage, but a few tins of condensed milk ensure a supply. One's home milkman will usually lend a gallon tin in which to fetch fresh milk. Eggs and butter may be procured from farms near; also fresh vegetables, and sometimes fruit. Candles, matches, and soap should not be forgotten. As beverages, Rose's Lime Juice Cordial and a store of lemons for lemonade are acceptable. The larder can usually be restocked at one of the large centres on the Broads."

Hotels. Hotel-keeping may be made fairly profitable when conducted on sound lines; but, with few exceptions, hotels rarely flourish under joint-stock companies. For one thing, there is temptation to dishonesty in the management, as well as uncertainty of goodwill. In an hotel the pervading personal influence, " the master's eye," is all potent, and under a board of directors the manager's hand is usually more or less held. Britishers are accused of being equally inefficient as waiters and private hotel-keepers; and women, it is contended, who might be supposed fit to undertake hotel management involving housekeeping on a large scale, fail to make a success of the concern. Extortionate charges, bad or monotonous cooking, want of attention, comfort and cleanliness are common complaints. Hotel management demands years of training and requires power of organisation, a good general education, business ability, tact, honesty, a pleasing personality, knowledge of foreign languages, and, of course, adequate capital.

For capable women there is an opportunity in the management of temperance hotels, situated preferably near a railway station, and sometimes the property of the railway company. The manager needs a good general education, a knowledge of cookery, a capacity for housekeeping, also acquaintance with bookkeeping and business methods. She will not then fall into the error of " cheeseparing " economy, due to want of foresight, ignorance, and timidity.

Managing a Temperance Hotel. The exterior of a temperance hotel should be bright and attractive, its windows clean, its curtains spotless, and its woodwork freshly painted. There should be no superfluous furniture, but what there is plain and artistic, with one or two really good pictures. The bedsteads should be of modern style, and the carpets or rugs of substantial make. The manageress greets incoming guests, attends to the entry of the luggage, offers refreshments, communicates the hours of meals, shows the bedroom, and sends a chambermaid with hot water. From arrival to departure, the guest is conscious of being served and considered in every way, and is aware that every detail of the management is carried out with equal efficiency. The manageress is near at hand when wanted, never too busy to answer questions, and equally able to arrange menus economically and satisfactorily, and to give information concerning the town and district. The hotel is not overstaffed, but each person is capable and obliging. In the case of a railway temperance hotel the cook, housemaid, head chambermaid, and commercial room waitress would manage others under them. In a small provincial town dairy produce is readily obtainable, and the manageress would, of course, do the catering herself, and, in the event of a garden being attached to the hotel, cultivate her own vegetables. In view of the increase of motor-car traffic, the coffee-room business might easily be improved. Repairs need constantly to be seen to, breakages replaced, linen and other accessories renewed. A combination of cracked tumblers, stumpy knives, torn sheets, and ill-cooked food is a pledge of failure.

Hotel Charges. It is a mistake to think that a large hotel necessarily makes high charges. Good temperance hotels in London charge from 3s. 6d. for bed-room, breakfast, and attendance.

Every hotel should have an arrival book, with spaces for the date, name of client, number of room, and entry of letters to be forwarded.

In America two systems of charges prevail—(1) the American, at two to three dollars a day for board and meals; (2) the European, at so much for the room, with cost of meals additional.

The subject of hotel management is so vast that only a few points of interest can be touched, and the reader's attention is directed to "Practical Hotel Management," published at 2s. 6d. by Messrs. Newton & Eskell, a book full of practical information and containing an interesting appendix on hotel law.

Hotel Catering. As in all catering, well-established, reliable butchers, bakers, and grocers should alone be dealt with, the bills being paid weekly or monthly, and weight and measure checked as the provisions are received. It is possible to estimate fairly accurately articles of regular consumption. For instance, for each person per day can be reckoned: Butter, 2 oz.; loaf sugar, 1 oz.; tea, ½ oz.; coffee, ½ oz.; bread, under 2d.; and meat, 1½ lb. (including in this allowance meat for soups, etc.). A bill of fare posted up every morning in the entrance hall with time required for preparing special dishes has been found serviceable.

The commissariat department can be made to yield a fair profit. Chefs, however, notoriously disregard expense, hence various methods are adopted to check extravagance: (1) The chef controls the kitchen staff and stores, and keeps accounts of the latter, which are checked nightly by two bookkeepers. He is paid a percentage, say 10 per cent., on the profits of the commissariat department, and is thus rewarded for economy. (2) According to the "mess system," the chef, again, controls the kitchen staff and purchases stores, but supplies them at fixed advance prices to visitors, say at one-fifth profit. As he pays for rent, hire of kitchen, and plant he is somewhat in the position of messman of a regiment. (3) The manager superintends the purchase of stores wholesale; these he hands to the chef, who on making up accounts at the month's end is allowed a small commission on profits besides his salary. (4) In certain small hotels the chef has a requisition book, and every evening enters his requirements for the following day. The storekeeper has his own book, and accounts are balanced monthly. In the two last cases the manager keeps control over the kitchen.

The Larger Hotel. In a large hotel with a staff of 100 to 120 servants the catering for them alone involves much labour and separate dining-halls; but under economical management their meals need cost little—say, 1s. a day. An hotel manager needs as much skill to control his little kingdom as a general does to command his army. In the modern palatial hotel, such as is increasingly taking the place of the town mansion of the opulent class, one may pay anything from £1 to £10 a day. The essential requisites for success are:

(1) A big capital—the ground property alone may be worth £50,000 to £100,000; (2) suitable situation on or near a main thoroughfare, and near theatres, clubs, and the best shops; (3) maximum of comfort; (4) efficient service; (5) excellent cuisine; (6) good sanitary arrangements.

The manager of such a gigantic concern needs to be thoroughly trustworthy, a financier, a linguist, a man of quick and accurate judgment, known abroad, and practically skilled in buying provisions. He will import from France fruit, vegetables, poultry, foie gras; from Italy, olive oil and eggs; from America, the West Indies, and British Colonies, fruit (apples, pears, peaches, pineapples, bananas).

A staff of 200 is common; it sometimes exceeds 400 or 500, waiters being in the majority. The amount of provisions consumed yearly is fearsome to contemplate. One hotel gives meat, 400,000 lb.; chickens 25,000 pieces; ducks, geese, and turkeys, 4,000 pieces; pigeons, 3,000 pieces; ortolans, 2,000 pieces; grouse, partridges, pheasants, 13,000 pieces; soles, 42,000 lb.; other fish, 30,000 lb.; ham and bacon, 47,000 lb.; butter, 47,000 lb., and eggs, 380,000.

A large hotel should have its model farm, for poultry and dairy produce. It is worth while for it to grow its own pot-shrubs and flowers, since the bill for these items may amount to a considerable sum a year. In every hotel a good plan of the building is a necessity; in fact, one in every room would be appreciated, for some general idea of the place is wanted in case of fire. To the uninitiated the basement of a big hotel is a bewildering labyrinth, where kitchens, workshops, engine-rooms, store-rooms, bakeries, refrigerating-rooms, pantries, and laundry form a maze.

If the catering department is to prove a success, too much stress cannot be laid on the necessity of checking, weighing, and measuring provisions. Where the chef is indifferent to this matter, abuses soon creep in. The ablest cook is often the most extravagant, and extravagance spells disaster. In hot weather special oversight of provisions is worth the extra trouble involved. Milk, meat, fish, and poultry spoil; they should, therefore, be stored in the coolest, best ventilated rooms with northern aspect, and a daily inspection made, when any suspicious parts should be removed. Cooked and uncooked meat should be far apart. A slab of marble with cold water trickling over it is best for fish. Avoid light and dryness for vegetables, which should be obtained fresh daily. Poultry, and all birds, in fact, keep best suspended by the legs, with a sprinkling of pepper under the wings and legs. An economical cook will make potted meats from the remnants of poultry, game, ham, etc., so that by the time the man who buys the kitchen waste appears on the scene no dishes retaining any possibilities need pass into his hands.

Wages of an Hotel Staff. The following particulars of wages paid to an indoor hotel staff of 72 are given in "Practical Hotel Management":

Housekeeper, aged 40 to 50, £40 per annum and laundress. Clerk £50.

Bookkeeper, aged about 30, £35 and laundress. Duties: Writing bills for the previous day, keeping day, cash, wages, ledger books, etc., and making out visitors' books.

Office Assistant, aged about 25, £25 and laundress.

Linen-keeper, aged about 40, £35. Duties: Care of linen, bed-hangings, furniture covers, etc., and visitors' washing. Assistant linen-keeper, £15.

Two barmaids, aged about 30, £25 each.

Storekeeper, aged about 25, £20. Duties: Making daily lists, assisting in office, linen-room, bar, dishing dessert.

Three chambermaids, one on each floor, £16 each; six housemaids, two on each floor, £14 each; stair and corridor maid, £20; staff-room maid, £18; vaultsmaid, 14s. a week, living out; basement maid, £20; two still-room maids, £24 and £18; kitchen-maid, £25; vegetable-maid, £20; pastrymaid, £20; scullerymaid, £15; odd maid, £18; five laundry-maids, £35 to £20; panman, 15s. weekly.

Head-waiters, 1st and 2nd, £1 1s. each per week.

Two assistant coffee-room waiters, four assistant table d'hôte-room waiters, each 14s.; six sitting-room waiters, 18s. each; steward's-room waiter and pantryman, each 14s.

Two platemen, £1 1s. and 14s. weekly; two billiard-markers, 14s. and 7s. weekly; two pages, 2s. 6d. weekly; hall-porter and second hall-porter, each 10s. 6d. weekly; head and assistant cellarmen, £1 10s. and £1 1s.; vaultsman and assistant vaultsman, £1 5s. and £1; engineer, £1 1s.; two night-porters, 15s. weekly, with two suits of livery; chef, £2 10s. weekly; baker, £1 1s. weekly.

Continued

CANE AND BAMBOO WORK

The Sources and Uses of Cane. Cutting Cane. Chair-making. Varieties of Bamboo. Growing, Collecting, and Working Bamboo

Group 23
APPLIED BOTANY
11
Following on BASKET-MAKING, page 5564

THE canes of commerce are yielded by plants of the genus *Calamus*, climbing palms. The term *cane* is often loosely applied to any form of plant with long, slender stems, reeds and small bamboos, but in this article it is used to denote the products of various species of calamus.

What Canes are Like. The plants yielding cane are graceful and are either in stunted erect bushes or long climbing plants, holding firmly on to the forest trees by means of prickly tendrils and attaining as much as 600 ft. in length. The fruit hangs in clusters and is partly eaten by hill tribes, although the bitter-sweet pulp is not relished by Europeans. The stems do not often exceed 1 in. in diameter, and when freshly cut contain a large quantity of liquid, which may be collected by blowing through short pieces. The roots and young sprouts are eaten as a vegetable, and somewhat resemble asparagus. The base of the stems is sheathed in leaves, and when collecting the cane the natives pull the stems through a notch in the trunk of a tree to clear off the leaves. On drying the canes turn yellow. The *rattan* cane is the particular variety with which we are now concerned. It is yielded by *Calamus rotang* (*Linn.*, *Roxb.*), and is found in India, Ceylon, Burma, and the Eastern Archipelago, in parts where the soil is rich and moist, and there are trees for it to climb on. This species yields the best and stoutest rattan canes of commerce.

Uses of Cane. The great strength and lightness of cane adapts it for a great variety of uses. The strength of the outer shiny layer, due to the silicates it contains, is particularly noticeable. Cane is used for ropes, cables, walking-sticks, spear and lance shafts, fishing-rods, basket work, chairs, sofas and couches, umbrella handles—as a substitute for whalebone — cane fabric, and chair-seating.

An interesting use for cane, which illustrates its length and strength, is the construction in India of cane suspension bridges. Carefully selected canes, 300 ft. to 400 ft. long, constitute the chains, and bridges of that length are often thrown across rocky valleys 500 ft. above the water. The bridge generally consists of three parallel canes forming the pathway, the canes being knit together with bamboo or bark so as to constitute a band not more than 18 in. broad. The railings afford additional support and consist of two canes carried about 3 ft. to 4 ft. above the pathway on either side. These are here and there connected by perpendicular canes passing under the pathway, and the whole structure is bound together by a network of bark ropes or smaller canes. With the weight of the traveller the bridge bends until it is often alarmingly near the water, and to prevent the railing closing on the person crossing the bridge, barriers are thrown across at intervals about 18 in. above the pathway, similar stays being also carried overhead.

1. BENDING CANES OVER A GAS FLAME
(G. Scott & Sons)

Cane-splitting. The practice of cutting cane into narrow strips for caning chairs is a European industry, but it has now been adopted in the East. The strips are cut either by hand or by machine. The hand method is to fix a sharp blade, such as a razor blade, above a bench, after the manner of a spokeshave. The cane is pushed through from one side and drawn out the other side, taking care to keep the cane down on the bench, with the thumb protected by a leather guard. The cane is first quartered, or split into four pieces, each of which is then further split. The fineness or coarseness of the strips depends on the distance between the bench and the blade. It is the outside layers that are used for chair seating, the inside part, known as the *wisp*, having other uses which will be alluded to presently. The lengths of cane strips are technically known as *skeins* and average about 6 ft. long, costing about 2s. 6d. a pound, the charge varying according to the fineness. The machines for splitting rattans work on similar principles to those noted above. There are feeding and grinding or controlling devices in conjunction with the splitting knife. The strip is often joined in a continuous length and a variety of reinforced cane-strip which has a filament glued on the back of the strip has been introduced to meet the demand for machine weaving. Machine-cut strips are very even and the central core is left in the form of a perfect rod. The wisp is sometimes reduced to fibre and used for stuffing mattresses.

Cane-seating. On examining the cane seat of a chair it will be seen to consist of strips from back to front and from the side, in pairs through each hole in the frame of the chair and single strips diagonally, the whole interlaced. The strands from the back to the front are technically called *doublings* and those from side to side *setting*, and the others, which, it will be noticed, are a little wider, are the *crossing*. The doubling is done first. Turn up the chair and it will be found that at one place the cane goes round the inner edge of the frame and a loop will be seen to denote the starting place. This loop is simply formed by turning the short end of the piece under the cane on the top and inserting in the hole. To prevent the cane slipping loose as the seat is being worked a tool called a *doubler* or *rimer* [4] is used. This consists of a smooth, steel spike, $2\frac{1}{2}$ in. long, tapering from a blunt point to $\frac{5}{16}$ in. at the tang, and firmly secured in a short, hard-wood handle. It exerts a wedge-like action when inserted into the holes. The cane strip is soaked in water for twelve hours to make it pliable

and to prevent cracking and splitting when lacing. As the cane contracts on drying the result is a firmer strand than would be obtained if dry cane were used. The end of the cane being held in place by the rimer, the cane is taken over to the corresponding hole on the opposite rail of the frame and pushed down through it, then up through the next hole and so on till the first strand of the doubling is completed. Then work the second strand in the same manner.

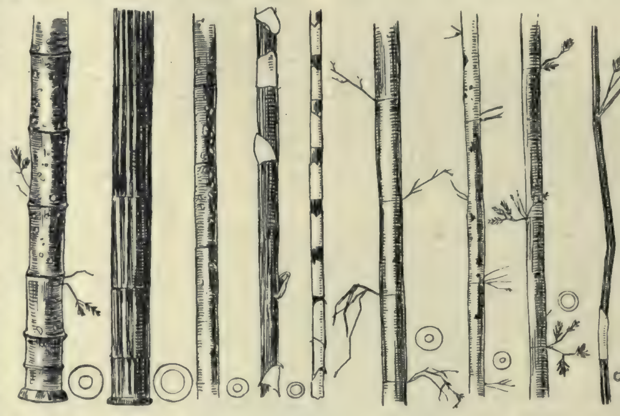
Setting and Crossing. Now proceed with the *setting*, but instead of working all round the chair with the first strand, before beginning with the second pass both together through the holes. Now, instead of pulling these across straight to the opposite hole, they are woven with the doubling by passing them alternately over and under each strip, for which a *caning blade* is used. A strip of stout tin serves well as a caning blade, as it is merely required to serve as a guide, up which the end of the strip of cane is directed, between two other strips. The *crossing* is done in the same way as the setting with the aid of a caning blade but, instead of being double, single strands of greater width are used. A spiral or corkscrew-shaped needle [5] is also used for the diagonals or crossing. When both sets of crossing are complete the weaving is finished and the worker has to make the cane firm by pegging alternate holes with wooden pegs. The pegs are hidden by a *beading* which runs round the frame over the holes. The beading consists of a strip of cane looped down by another piece worked through the holes left free from pegs and serves merely to give a finish to the chair.

Close Weaving and Compressed Cane. Close weaving, such as is seen on railway carriage seats, is done by machinery. One machine produces the *mat*, or foundation, and a second inserts or weaves in the diagonal strands. A knitted fabric has also been produced; it is composed of looped cane, the outer parts of the loop being indented or crimped so as to minimise the chances of breaking. Cane in its natural state is easily bent by placing it in boiling water or hot sand, or heating by means of a flame [1]. This softens the cane, which is tied in the position it is desired to assume and left to cool. The cane blinds which exhibit geometrical designs are prepared in this way.

Of late years considerable quantities of cane have been used in the construction of trunks and dress baskets. Such trunks are exceedingly strong and stand a good amount of hard usage without injury. The central part of cane obtained by stripping off the outer layer is softened by soaking in water or lye. It becomes by this means pliable and is then mashed or flattened between a pair of rollers through which it is drawn. The strips used for cane trunks are from ¼ in. to ½ in. in width and are laid down between canvas.

Other Canes. Malacca canes are obtained from *Calamus Scipionum Lour.*, a native of Sumatra and Cochin China. The colour is due to a smoking process to which the canes are subjected. Whangee cane is the jointed stem with a portion of the root of *Phyllostachys nigra*, but is not a real cane. Various kinds of cane substitutes which pass as cane are the product of the betel nut palm, the palmyra palm or the coco-nut palm.

Bamboo. The plants that produce bamboos are gigantic but graceful grasses of the tribe *Bambuseæ*, natural order *Gramineæ*. A great variety of bamboo trees are known [2]; General Munro has described 170 species, and the botanist Kurz has dealt with the species, but much yet remains to be done before the subject can be said to have been exhausted. The following are the more important genera to which members of the bambuseæ have been referred: *Arundinaria, Mich.*; *Bambusa, Schreb.*; *Gigantochloa, Kurz*; *Oxytenanthera, Munro*; *Dendrocalamus, Nees*; *Melocalamus, Benth.*; *Pseudotostachyum, Munro*; *Teinostachyum, Munro*; *Cephalostachyum, Munro*; *Dinochloa, Buse.*; *Melocanna, Trin.*; *Ochlandra, Thw.* It is well, also, to indicate briefly some special kinds of bamboo. *B. arundinaceæ* is sometimes called *the* bamboo; *B. vulgaris* is known as the common bamboo, and is common in Java, and cultivated in India. The term "male bamboo" is applied to any solid bamboo used for spear or lance staves, more often to *D. strictus*; the black bamboo is *P. nigra*, the dark blotches being due probably to some fungus; the edible bamboo is a variety specially grown in Japan for food, the young shoots being boiled and eaten with cream sauce; the square bamboo is *Bambusa quadrangularis Fenzi*. The last-named variety has been cultivated from a kind which showed an unusual tendency to flatten at the nodes. The spiny bamboo is *B. spinosa*, in which buds have solidified to spines. Bamboos are found in Japan, China, India, and the Eastern Archipelago, being both cultivated and found wild.



a b c d e f g h i

2. SOME VARIETIES OF BAMBOO

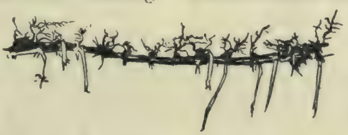
a. Bambusa aspera *b.* Gigantochloa mascima *c.* G. atter *d.* and *e.* G. apus *f.* B. blumeana *g.* B. vulgaris var. *h.* Schizostachyum brachycladum var. viride *i.* B. rumphiana

What the Bamboo is Like. The stem of the bamboo is practically of the same thickness throughout, and, except at the nodes, is hollow. Certain special varieties usually of small diameter are, however, solid, but for practical purposes the

"culms" may be regarded as hollow. Bamboos grow in clusters, in clumps, or in a continuous manner. A clump consists of from 30 to 100 culms, which attain a height of from 30 ft. to 150 ft. The clumps are often so closely packed together as to form an impenetrable jungle. A peculiarity of the bamboo is the rapid growth of the young shoot, the shoot increasing 3 in. to 6 in. daily, and attaining its full height in from 30 days to 3 months. A peculiarity about the bamboo is that the plant only flowers when 25 or 30 years old, and that the flowering is almost always followed by the death of the whole plant.

3. METHODS OF JOINING BAMBOO

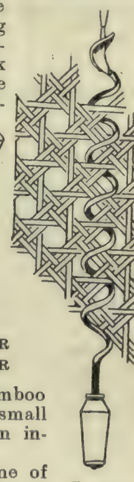
Propagation. The bamboo is propagated either by seed or by cuttings, the latter being the readiest method. The best way to proceed is to cut from a one-year-old stalk one of the nodes with its branch, and place it in water in a cool, shady place. During the summer, roots [6] will be produced at the node, and in the autumn the cutting is planted in a moist, shady ground. Later on, when the cutting has made stronger roots, it may be transplanted to open ground. If cared for when young, mulched with leaves, and carefully watered, the bamboo may be grown anywhere, some varieties standing 8° to 10° of frost. In Florida, the bamboo attains a large size. New shoots appear in July, and in nine to ten weeks the shoots will often have reached a height of 70 ft. Though produced in a few weeks, a stem requires three to four years to harden and become fit for use. If left standing too long, or until the stem becomes yellow, it loses its elasticity. It is a rule not to cut bamboo till it is four years old. In Japan harvesting is done in August; if earlier, the stems are likely to be attacked by insects. A saw is often used in cutting the stems, and after cutting they are then classified, tied into bundles, and stacked to dry.



6. BAMBOO RHIZOME

Properties and Uses. The many uses of bamboo make the plant one of the most valuable in the vegetable kingdom. The stems can be made into a continuous tube by an iron rod through them, and these tubes can be put to many uses, such as conveying water. A large bamboo sawn at the node makes a useful bucket or similar vessel. In the interior of the hollow stems of some bamboos, chiefly *B. arundinaceæ*, a silicious and crystalline substance is found, known in the bazaars of India as *tabashir*, or bamboo manna. It is used as a medicine in lung diseases. Bamboo has been recommended as a material for the manufacture of paper, but the hard hairs that cover the scales and young stems have been found to diminish the value of the stock as a papermaking material. Santos Dumont employs bamboo for the framework of his dirigible balloons. Some other uses that may be mentioned are: whitewash brushes, carrying-poles, pegs, pins, basket work, mats, spoons, ladles' agricultural implements, fishing-rods, bows and arrows, man-traps, sword and umbrella handles, walking-sticks, ladders, garden poles, curtain poles, window blinds, fans, and musical instruments. Plugged with hard wood and pointed, bamboo is used for garden stakes, and small bamboo twigs are finding an increased use for pot training.

4. RIMER OR DOUBLER

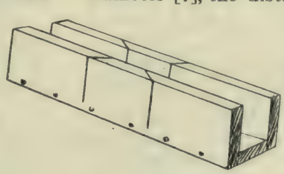


5. SPIRAL NEEDLE

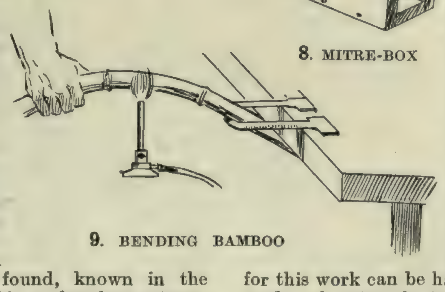
Bamboo Furniture. One of the chief uses of bamboo in Europe is the manufacture of furniture. Cheap and durable articles of domestic use—chairs, tables, sofas, and the like—can readily be made from bamboo, the many different kinds and sizes of the rod that are available making it easy to obtain bamboo of any desired structural strength. The imported bamboo is known in the trade by its colour, such as tortoise-shell, natural brown, black and mahogany, some of the fancy kinds being artificially produced.

Tools Required in Working Bamboo. A few special tools are needed by the bamboo worker in addition to a small dovetail saw, bradawls, brace and bits, and gluepot. A few bamboo rasps are required from $\frac{3}{8}$ in. to 2 in. diameter [7], the distinguishing feature of these rasps being the high back. Their purpose is to hollow or round out the ends of bamboo canes to make a joint with another cane. A mitre-box [8] is preferable to the mitre-board where angles have to be made. The illustration showing the joining of bamboo is self-explanatory. The process of bending bamboo consists in heating the outside of the bamboo in a smokeless flame, such as a spirit lamp or Bunsen burner, and gradually applying pressure in the direction desired. A bending iron such as is used for this work can be had for a few pence, and the mode of using it is readily grasped from the illustration [9].

7. SECTION OF RASP



8. MITRE-BOX



9. BENDING BAMBOO

Cane and Bamboo Work *concluded ; followed by* Brush-making

Continued from page 5576

ORCHESTRATION

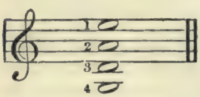
A Brief Survey of Orchestral Instruments in General Use. Their Compass, Peculiarities, and Limitations. Transposing Instruments

By PAUL CORDER

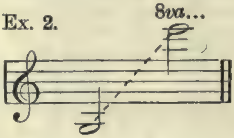
ORCHESTRATION, or instrumentation, is the art of arranging and distributing music suitably among a number of different instruments. Before we can do this satisfactorily we must know, (1) the number and names of the instruments at our disposal; (2) the compass, and, roughly, the technical capabilities of each instrument; (3) the quality of sound, or *tone-colour* as musicians call it, of every instrument, not only singly but in combination with every other instrument. We must furthermore possess such elementary knowledge of the theory of music as can be obtained by studying the course in this work [page 37]. It will be assumed that the student is familiar with this. Let us, then, turn our attention to the constitution of the orchestra.

Of the large number of different instruments in existence certain combinations only, by a species

Ex. 1.



Ex. 2.



of natural selection, seem to have survived, and, with sundry modifications, to form the principal types of orchestra that are now to be met with. We may classify these arbitrarily into the full orchestra, the small orchestra, the theatre band, the string band, the wind band, the brass bands. It will not be advisable to analyse these in detail until we have learned something about the instruments that make up the various orchestras.

All instruments in general use can be grouped naturally under one of four heads: Strings, wood-wind, brass, and percussion. There are, however, a few miscellaneous instruments less frequently used that defy this classification.

The stringed instruments, called briefly the Strings, although the most important group, contain but four members. They are those instruments played by means of a bow—namely, the violin, of which there are two groups in the orchestra, called 1st and 2nd; the viola; the violoncello and the double-bass, all of which are different sizes of what is practically the same instrument.

Ex. 3. *Con fuoco*

The wood-wind, which are by no means always made of wood, are those instruments wherein the sound is produced by means of the player's breath through the medium of a reed or other contrivance. The principal types of this group are the flute, oboe and clarinet.

To the brass belong those powerful instruments of metal whereof the horn, trumpet, and trombone are the representatives.

The percussion instruments are, as their name implies, such as depend for their sound on being struck. The majority of these produce no musical note, and hence are of comparatively little importance.

Of the varied uses to be made of these we shall speak later, after the compass and peculiarities of each instrument have been separately described.

THE STRINGS

In the first place, then, we must consider the strings.

The Violin. The violin has four strings tuned in fifths [Ex. 1]. All intervening notes are produced by pressing the fingers of the left hand on the strings, which are thus temporarily shortened, and the pitch, in consequence, correspondingly raised. The successive use of the four fingers on each string will produce a scale of two octaves and a third, but, by shifting the hand along the neck of the instrument, higher notes can be reached, the complete compass being nearly four octaves [Ex. 2]. The highest notes are difficult to play in tune and are best left to soloists, but it is hard to assign a limit for orchestral purposes. Much depends upon the passage and still more upon the players; the 1st violins in a modern orchestra are often expected to play up to high E, but the 2nds should not be taken above A.

A slight knowledge of violin playing will show that it is not advisable to write quick passages containing large skips unless these are to an open string, but anything in the nature of a scale passage is perfectly easy provided it is not too chromatic (for the same finger has at times to play both sharp, flat and natural). It will, perhaps, be helpful to give a quotation showing what to avoid in passage writing. Ex. 3

is exceedingly difficult: whereas the example below [4] is not at all hard.

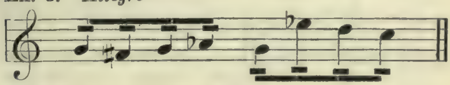
The violin has (and indeed all the stringed instruments have) an immense range of tone, from *pianissimo* to *fortissimo*, and that throughout its entire compass.

Unless otherwise indicated each note will be played with a separate stroke of the bow. This detached bowing is often most effective; in quick passages it imparts a very exciting movement to the music, although at a very high rate of speed it is difficult for all the players to keep together. If several notes are required to be played in one bow a slur is used over such notes as shown in Ex. 4, where eight notes are taken to each bow.

Ex. 4. *Lento f*

The composer should be careful to mark the slurs wherever he requires them. A useful effect is that of double-bowed notes, where each note is played twice or oftener, by means of short rapid strokes; it is written as shown in Ex. 5. Or a further variety of the same kind, called the tremolo, requires each note to be repeated as

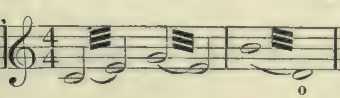
Ex. 5. *Allegro*



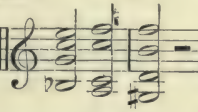
rapidly as possible [Ex. 6]. A legato tremolo is also used; it is more effective in *piano* [Ex. 7]. As the two notes must be on one string the interval should not exceed a fourth, unless the lower one is an open note.

Ex. 6.

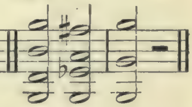
Ex. 7.



Ex. 8.

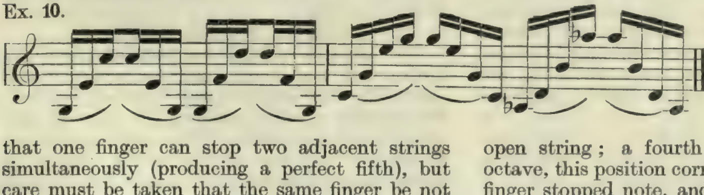


Ex. 9.



By inclining the bow so as to touch two adjacent strings, double notes are rendered possible, but must not exceed an octave unless the lower note is an open one. In any case double stops should not occur in quick succession; as an alternative the violins may be divided, half the players taking each part. Triple and quadruple stops are occasionally written, but it is advisable to see that one, if not two, of the notes are open strings. It must be borne in mind that one finger can stop two adjacent strings simultaneously (producing a perfect fifth), but care must be taken that the same finger be not required on strings which are not next to one another. The chords in Ex. 8 are impossible, while those in Ex. 9 are quite easy. Triple and quadruple stops may be broken up into an arpeggio form [Ex. 10], but they must be laid out precisely as if the notes were to be played simultaneously.

Ex. 10.



The tone of the violin can be muted by fixing a little metal clip to the bridge. This is indicated in the music by the Italian words *con sordino*, and has the effect of entirely altering the tone of the instrument. In place of its former resonance it acquires a nasal, whining tone which on a large body of instruments has a mysteriously beautiful effect, more especially in soft passages. It should, however, be used with reticence. A few bars' rest must be allowed for the players to adjust their mutes, and a shorter rest to remove them (*senza sordini*).

Another useful violin effect is that known as *pizzicato* (abbreviated to *pizz.*). In this the bow is dispensed with, and the strings are plucked with the forefinger of the right hand, in the manner of a guitar. If discreetly employed it has a very light and pleasing effect. It is better not to write for it on the highest notes, as the tone is hard above "C in alt." The bow is resumed on the indication *arco*.

Other violin effects of less importance are *sul ponticello* and *col legno*. By playing close to the bridge a peculiar hissing tone is produced, especially in tremolo in the lower part of the instrument. When *col legno* is written, the strings are tapped with the back of the bow, instead of being played in the usual manner.

By lightly touching the string at any aliquot part of its length ($\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, etc.) peculiar flute-like tones result, known as harmonics. The notes will not necessarily be those which would result by stopping the string at the same point. Half the string gives its octave (similar to the stopped note); a third part will sound a twelfth above its open string; a fourth part gives the double octave, this position corresponding with the third finger stopped note, and from this last fact has been developed what are called *artificial harmonics*. Since lightly touching the string with the third finger gives a harmonic two octaves above the open string, by stopping a note with

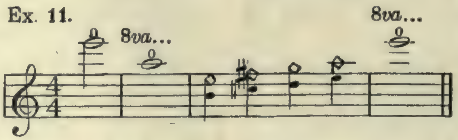
the first finger and touching the string with the fourth the harmonic will be two octaves above the stopped note; and by sliding the hand into higher positions, and proceeding similarly, a complete scale in harmonics can be played. In the orchestra harmonics (especially artificial) must be used with extreme care. The method of indicating them is rather uncertain; but natural harmonics are best marked with a circle over the note [°]; for artificial ones, both the stopped note and the touched note are generally written, the latter with a square head, and sometimes the result is likewise shown. We give an example [Ex. 11].

The Viola. The viola is a larger-sized violin, having its strings tuned a fifth lower. It usually takes the tenor part of the string quartet—the second violins supply the alto. Nevertheless, it has valuable qualities as a melodic instrument, and if it is seldom allowed to fulfil this function, it is solely on account of the paucity and weakness of viola players in the majority of orchestras.

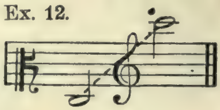
Music for the viola is written in the alto clef, except for its highest notes. Its compass in the orchestra is about three octaves [Ex. 12]. Its tone is inferior to the violin, besides being far less penetrating, and it requires great care, if it is given a solo passage, to enable it to stand out from the rest of the strings.

All that has been said of the violin will apply equally to the viola, except such as concerns its actual pitch. It is well accustomed to double and triple stops for the purpose of filling in the middle part of the harmony, but it is less advisable to divide them, except for a special effect.

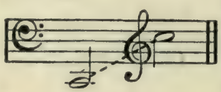
Ex. 11.



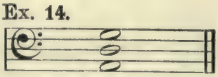
Ex. 12.



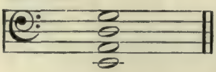
Ex. 13.



Ex. 14.



Ex. 15.



The Violoncello. The violoncello has its strings tuned an octave below the viola, but it has a larger compass than that instrument; indeed, it is hard to fix a limit to the 'cello's high notes as a solo instrument, but for orchestral purposes it is best kept within the compass shown in Ex. 13. Three different clefs are used —the bass, tenor (not alto), and, for the highest notes, the treble. Owing to the greater length of the strings, the distance between the notes is about double that of the violin, and, in consequence, fewer double stops are available, nor are they so effective as on the higher-toned instrument.

The normal function of the 'cello is the bass of the string quartet, but it has such a sonorous, singing tone in its higher register that it is invaluable for melodic purposes in the orchestra. Wagner and other composers have sometimes written harmony for 'cellos in four and five parts, and the effect is extremely beautiful. Mutes may be used on the 'cello, and the other effects described for the violin (including natural harmonics) are also available.

The Double-bass. It was formerly the custom for the double-bass and the 'cello to play from the same part, the effect being to strengthen the bass of the harmony as supplied by the 'cello, for the bass always sounds an octave below its written notes—and, although it is still usual, to a large extent, to find the bass and 'cello playing together, there are many occasions on which they require to be quite independent.

There is some uncertainty as to the tuning of the double-bass. The three-stringed instrument, which is now seldom seen, was tuned as shown in Ex. 14. The bass in most frequent use in this country is the four-stringed one, the tuning of which is generally given as in Ex. 15, sounding an octave lower; but of late years double-bass players have been accustoming themselves to tune the fourth string down to D. This is a great convenience in the many works where notes below E have been written. For composers have always disregarded the compass of the bass; Beethoven and others have frequently written it with the 'cello down to C, necessitating awkward alterations of his parts. The upward limit should not exceed that given in Ex. 15.

The tone of the bass is rather thick and "woolly," and it is better to have some other instrument playing with it (in the octave above), unless the peculiar effect of double-basses alone is desired. Rapid passages are for the same reason ineffective, besides being difficult.

Double notes, besides being difficult to play, are quite ineffective so low down, and it is more advantageous to divide the basses on the rare occasions when more than one note is required of them. The two effects of *tremolo* (bowed) and *pizzicato* are even more useful than on the violin, but it should be remembered that a tremolo continued for any length of time is excessively fatiguing to the player. A *pizzicato* bass may often be employed while the rest of the strings are playing *arco* to produce a light and pleasing bass to the harmony.

THE WOOD-WIND

We have now arrived at a consideration of the instruments that come under the head of Wood-wind. The chief varieties may be tabulated thus: Flute, oboe, clarionet, saxophone, bassoon, and their numerous varieties. Before entering upon a description of these a few words concerning transposing instruments will not be out of place. This is a matter that causes endless confusion to the student of the orchestra, but if he will take the trouble to grasp the principle underlying this practice he will cease to consider it as an ingeniously-devised puzzle, and will realise that

the custom has some practical use, although less now than formerly.

Briefly, then, the matter stands thus. A standard instrument having been made which gives normally the scale of C, accidentals being produced by means of extra keys, it is said to be in C, at normal pitch, and gives sounds corresponding to the written notes. If another instrument be made, similar but of larger size, so that the keys that corresponded to the scale of C with the standard instrument now sound a scale of F, a fifth below, this instrument is said to be in F, a fifth below pitch. And by writing the notes as if they were to be played on the C-type (a fifth higher than they sound), the same player can use either instrument with equal facility, or any other of a different pitch. In other words, the composer has to transpose the music at his leisure to save the player the trouble of doing so at sight. The student will perhaps more easily comprehend the necessity for this if he imagines himself accompanying a violinist on a piano that has been tuned a semitone too high; it will save him infinite trouble if his music is transposed half a tone lower, so that he appears to be playing in B while the violinist performs in C, and he will then have a good example of what happens in the orchestra with a transposing instrument.

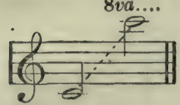
The Flute. The flute is a cylindrical tube of wood or metal (occasionally of other material), about 2 ft. long, whose source of sound is the column of air contained in it. This is set in vibration by the player blowing across a hole provided for the purpose. Other holes in the instrument are covered and uncovered by means of pads and keys attached thereto, which are operated by the fingers of both hands. By this means a complete chromatic scale for one octave is produced. By the adroit management of the player's breath, these notes can be made to sound an octave higher, and even a third octave can be obtained with cross fingering. Example 16 shows the complete compass. The two highest notes are difficult and very uncertain.

The flute has great facility of execution; shakes, scales, chromatic and otherwise, present but little difficulty; but, except in the extreme high notes, its tone is not powerful, and in a *tutti* it is quite inaudible. The term *tutti*, it will be remembered, is used to denote a passage wherein the whole orchestra is employed, such passage being almost invariably loud and full. With a sufficiently light accompaniment, its tone in the lower register is singularly pure and sweet.

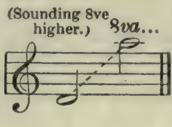
There is a flute of half the normal size and having a pitch an octave above the concert flute, called the *Piccolo.* The two lowest notes are wanting, and the very high notes are so shrill and hard to play as to be of little use. Its compass is given in Example **17**. The music is always written an octave lower than it sounds. The lower octave is weak; in fact, the chief use of the instrument is to continue the high notes of the flute. It should be used with reticence, and it will sometimes be found effective in brightening up a *tutti.*

Other varieties of flutes, such as those used in military bands, need not here be considered; but a bass flute in G, a transposing instrument a fourth below pitch, may be mentioned, though it is but seldom met with.

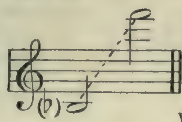
Ex. **16.**



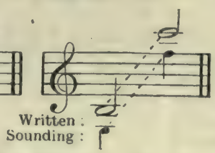
Ex. **17.**



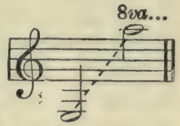
Ex. **18.**



Ex. **19.**

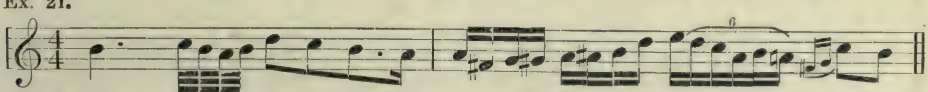


Ex. **20.**



The Oboe. The oboe is sometimes called the hautboy, which is a corruption of the French "Hautbois." This instrument differs from the flute chiefly in the manner of producing the sound. This is by means of what is called a double reed, which consists of two thin slips of cane placed close together and connected with the wooden cylinder of the oboe. By blowing through the reed, the air in the tube is set in vibration, and the penetrating nasal tone peculiar to the oboe is produced. The fingering and mechanism are of the same type as for the flute, but its compass is less extensive [Ex. **18**]. The low B♭ is not found on all instruments. The tone of the oboe is less suited to rapid passages, which, however, it is quite capable of performing, than to a plaintive melody, and, from its connection with the ancient shepherd's pipe it is used frequently for music of a pastoral character.

Ex. **21.**



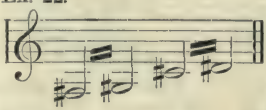
There is a larger sized oboe in F in frequent use, which usually goes by the name of the *Cor Anglais;* the equivalent, "English Horn," is seldom used for fear of confusion, since the instrument is neither specially English nor (most certainly) a horn. One feels tempted to wonder why the name *Alto Oboe* was not thought of till too late. Its tone is similar to that of the oboe, but even more hollow and nasal—the lower notes especially so. It is a transposing instrument, sounding a fifth lower than the written note; we give the compass [Ex. **19**]. Quick passages are quite unsuited to this instrument.

The Clarionet. Although bearing some resemblance to the oboe, the clarionet has many points of difference. Instead of the double reed, it is furnished with a somewhat stouter single

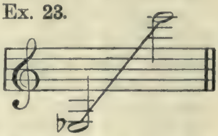
reed, which vibrates against a hollow box shaped suitably for a mouthpiece. It has, furthermore, this important difference : instead of its primary compass being an octave, as with the flute and the oboe, the clarinet overblows at the twelfth—that is to say, in its second register each key sounds a note a twelfth above its primary sound. The full compass is over three octaves [Ex. **20**]. Its tone in the lower register is exceedingly rich and mellow, which fact is attributed to the single reed. The second register is brighter, yet still rich and pleasing, and the high notes are even inclined to be shrill ; but just in the middle, at the break in the registers, there are a few notes of rather inferior quality. It is, of course, impossible to avoid this part, but it should be borne in mind that a passage such as that shown in Ex. **21**, will not only be uncomfortable to play, but will show the instrument to the least advantage.

It is unfortunate that the clarinet at normal pitch has fallen almost entirely into disuse, the two most generally written for nowadays are the B♭ and the A clarinets. The former, perhaps the more popular of the two, is a tone below pitch, and the compass is therefore a tone below that given in Ex. **20**. The A clarinet effects a corresponding transposition, sounding a minor third below the written notes. It is customary among composers to use (arbitrarily) the B♭ clarinet when writing in flat keys, and the A for sharp keys ; but some players prefer to use the B♭ instrument for everything, to save themselves the trouble of carrying about the two, thus disregarding the composer's directions ; instruments are now made with a low E♭ key, so that the compass shall be equal to the A clarinet.

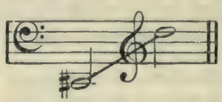
Ex. 22.



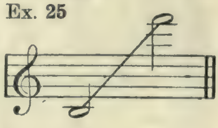
Ex. 23.



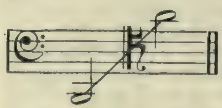
Ex. 24.



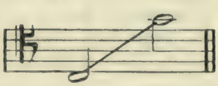
Ex. 25



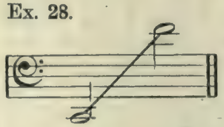
Ex. 26.



Ex. 27



Ex. 28.



The clarinet has considerable facility of execution ; arpeggio passages are more suitable to it than to most wind instruments, and, with the exception of a few awkward shakes [Ex. 22], it has unbounded command over its whole compass.

There are several varieties of clarinets beside those already mentioned that are occasionally found in the orchestra. A high clarinet in E♭, a minor third above pitch, and one in D, have been used by Richard Strauss and others. The tone of both these instruments is shrill and unpleasant ; they should only be used for special effects. More useful are the lower pitched instruments. One in F, a fifth below pitch, is sometimes called the *Basset Horn ;* it is a great pity that it is so little used. It is made with extra keys, which extend its compass down to C (written note). Unless otherwise stated, it may be assumed th all the varieties of clarinet have the san written compass.

The finest of all the clarinets, apart from the standard A and B♭ instruments, is undoubtedly the *Bass Clarionet.* It is usually made in B♭ (though composers have sometimes written for it in A and C), an octave below the ordinary clarinet ; but, true to the conditions of transposing instruments, and despite the fact that the ordinary clarionetist cannot play it offhand, the compass is given as shown in Ex **23.** This sounds a major ninth lower [Ex. **24**]. The low E♭ key is usually provided so that the A clarinet may be dispensed with. It is a pity that this fine instrument has not obtained a more permanent position in the orchestra, but the student is earnestly advised to write for it if there is the remotest prospect of its being provided. Its low notes are exceedingly full and rich, it has an invaluable melodic quality in the bass and tenor register, and it blends far better with the rest of the wood-wind, and forms a more satisfactory bass to it than does the bassoon.

On account of the length and weight of the levers and keys rapid passages are difficult, besides being ineffective ; the sombre tone of the instrument is far more suited for sustained work.

There is said to be an instrument still an octave lower, called the *Pedal Clarionet,* but few people appear to have seen or heard of it.

The Saxophone. A brief reference to this instrument will suffice, as it is but seldom heard in the concert orchestra.

The saxophone is a species of clarinet, from which it differs in having a conical bore instead of cylindrical. This fact accounts partly for its tone, which is fuller and coarser than the clarinet's. It is made in metal, and in six sizes for concert use :

Sopranino in F, a fourth above pitch.
Soprano in C, at normal pitch.
Contralto in F, a fifth below pitch.
Tenor in C, an octave below pitch.
Baritone in F, a twelfth below pitch
Bass in C, two octaves below pitch.

There is also a similar series in E♭ and B♭ for military use.

The compass, as regards written notes, is shown in Ex **25.** These are the actual sounds only of the soprano saxophone in C. They all overblow at the octave, not at the twelfth, like the clarinet.

The Bassoon. The bassoon is an instrument of the same type as the oboe, played in the same manner with a double reed. It usually

forms the bass of the wood-wind, but its compass is so extensive that it is well able to fulfil other functions than this. Music for the bassoon is written in the bass and tenor clefs [Ex. 26]. It is quite possible to obtain notes above this, but it is rather dangerous to write such for the orchestra unless the player is above the average. Unless the bassoon is well played its tone is apt to sound coarse and harsh; on the lowest notes it is next to impossible to play really *piano* (some players never succeed in doing so on any part of the instrument). The best part of its compass is shown in Ex. 27. It is well able to play quick passages, but these, if written low down, sound grotesque and even comic, which fact has been taken advantage of, more especially by Beethoven.

The double bassoon is an instrument of twice the length, folded in four for convenience, and sounding an octave below the bassoon, but with a more restricted compass [Ex. 28]. These notes all sound an octave lower than written. What was said about the lower notes of the bassoon applies still more strongly to the double bassoon. Its only use is to reinforce the bass of the wind harmony (which it does very inefficiently); but unless doubled in the octave above its lowest notes are quite indistinguishable, and the clattering of the reed is all that is audible. The pedal clarionet would be a vastly more useful instrument.

THE BRASS INSTRUMENTS

We now arrive at the third group of instruments. There are so many of these used only in military and brass bands that we can spare space to consider but a selection of the most useful. Those which appear in the concert orchestra are the horn, trumpet, cornet, trombone, and saxhorn, or tuba.

The Horn, or French Horn. This important and useful instrument consists essentially of a tube of brass about 8 ft. long, of conical bore, coiled up for convenience, and furnished at one end with a mouthpiece, also conical but inverted, the other end opening out into a wide "bell." By means of varying the pressure of the air that issues from the player's lips the series of notes given in Ex. 29 is produced. This is termed the scale of natural harmonics.

The modern horn is, furthermore, furnished with a mechanism consisting of a series of extra lengths of tube and valves so contrived that on depressing one or more of three pistons attached to the valves these tubes are put in connection with the main air-column, by this means lowering the pitch of all the harmonic series from one to six semitones.

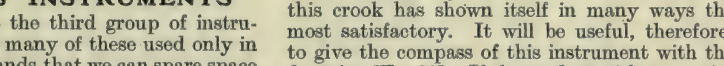
The 2nd piston lowers the pitch 1 semitone.
The 1st piston lowers the pitch 2 semitones.
The 3rd or 1st and 2nd combined, 3 „
The 2nd and 3rd combined, 4 „
The 1st and 3rd combined, 5 „
The 1st, 2nd, and 3rd combined, 6 „

By this means all the gaps in the harmonic series can be filled in, and a complete chromatic scale obtained.

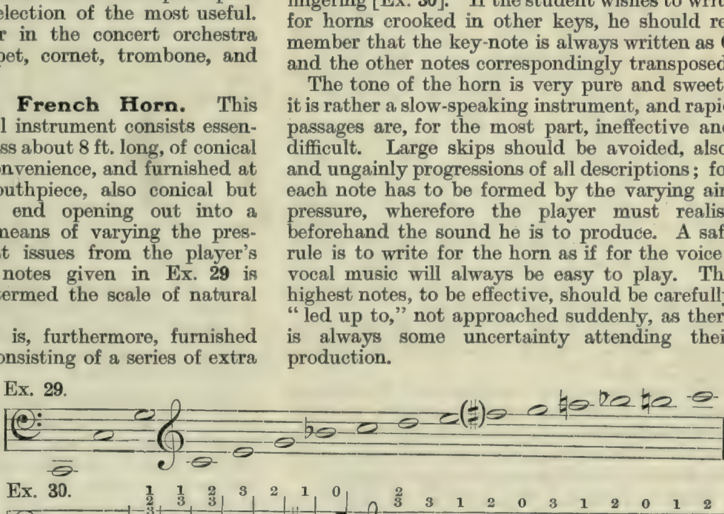
We have now to attempt an explanation of a very puzzling matter. Before the invention of the valve mechanism just described there was no means of altering the pitch of the harmonic series except by adding a fresh coil of tube, called a "crook," which merely had the effect of producing the same series of harmonics in another key. Therefore the composer had to direct his horn players to crook their instruments in whichever key would give him the most useful notes; and by having several players with differently crooked horns it was possible to obtain an approximate diatonic scale, at all events in the upper part of the instrument. For the convenience of the player the part was always written as if for a horn in C, but the sound varied according to the crook. The clumsy practice has been rendered quite useless with the advent of the valve horn, but it is necessary to refer to it, as the custom of crooking horns in various keys still continues to some extent. But the majority of modern composers write almost exclusively for the valve horn in F, as this crook has shown itself in many ways the most satisfactory. It will be useful, therefore, to give the compass of this instrument with the fingering [Ex. 30]. If the student wishes to write for horns crooked in other keys, he should remember that the key-note is always written as C and the other notes correspondingly transposed.

The tone of the horn is very pure and sweet; it is rather a slow-speaking instrument, and rapid passages are, for the most part, ineffective and difficult. Large skips should be avoided, also, and ungainly progressions of all descriptions; for each note has to be formed by the varying air-pressure, wherefore the player must realise beforehand the sound he is to produce. A safe rule is to write for the horn as if for the voice; vocal music will always be easy to play. The highest notes, to be effective, should be carefully "led up to," not approached suddenly, as there is always some uncertainty attending their production.

Ex. 29.



Ex. 30.

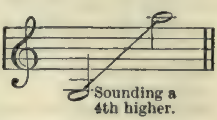


A "first" horn player accustoms himself to the higher notes, and should seldom be taken below middle C, whereas the "second" horn is used to the lower notes, and is generally unsafe more than an octave above this. When four horns are used in the orchestra they should be considered as two pairs—that is, the third horn should be above the second.

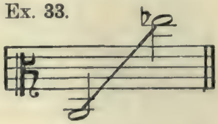
For some occult reason, it is customary to write horn (and trumpet) parts without key signature, marking in the accidentals as they occur, and if anyone is bold enough to break away from this tradition he must expect to hear an unusually liberal supply of wrong notes.

A curious effect can be produced on the horn by inserting a pad in the bell of the instrument, partially blocking it up. This is called a mute (*sordino*), and its use entirely changes the horn's characteristic tone. Played *piano*, an ethereal, far-away sound results; in a *forte* the tone becomes terribly sinister, and of a quality that must be heard to be appreciated. Incidentally, the use of the mute raises the pitch of the horn (or, according to some authorities, lowers it); but this is a matter which concerns the player more than the composer. These stopped notes, as they are called, are often indicated by a small cross (+) over them, or a passage of any length would be marked *con sordino*.

Ex. 31.



Ex. 33.



The Trumpet. The trumpet is an instrument of the same character as the horn, but with a tube of half the length, and consequently a pitch an octave higher. The brilliant tone of the trumpet is said to be due to the shape of its mouthpiece, which is hemispherical, or cup-shaped, instead of conical. It is generally written for in F, a fourth above pitch, though it may, like the horn, be crooked in other keys. It is provided with a similar valve mechanism. Example **31** gives the compass. Some players can obtain higher notes, but they are very shrill and overpowering, even if well played. It is more agile than the horn, though less so than the cornet, next to be described.

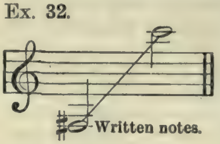
The trumpet may be muted in the same manner as the horn, and with a similar result as to its tone in forte.

On account of the smallness of its bore in proportion to its length it is impossible to sound either the fundamental note or the first harmonic, and its brilliancy is partly due to the fact of its notes being produced from the upper harmonics.

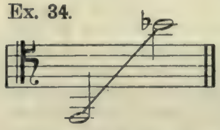
The Cornet. The cornet, on the other hand, has its tube half the length of the trumpet, and, as its bore is larger, it makes use principally of the lower notes of the harmonic series. Although this necessitates the sacrifice of much of the trumpet's brilliancy, yet this is in some measure compensated for by the increased facility of execution. Hence it is far easier to find a good cornet player than a fair trumpeter, and, except in the full orchestra, the cornet has to a great extent supplanted the older instrument. The cornet is usually made in B♭, with a crook to convert it into A, which is useful when sharp keys are employed. These transpositions correspond to those of the clarionet; its compass in the orchestra is given in Ex. **32**.

A good player can perform wonders of execution upon it—shakes, scales, and cadenzas presenting but little difficulty. One special effect may be mentioned, that of a quick repetition of a note, called double-tonguing. This is analogous to the double-bowed notes of a stringed instrument, but the effect is more staccato.

Ex. 32.



Ex. 34.



The Trombones. The trombones are the most powerful of all the brass instruments. They are of the same type as the trumpet, but the mechanism for altering the length of the tube is different. Instead of the valve and pistons of the other brass instruments, the trombone is provided with a sliding elbow-joint (similar to the tuning slide of a horn), by means of which the pitch may be lowered from 1 to 6 semitones. There are supposed to be three sizes of this instrument in use at the present day—the alto in E♭, the tenor in B♭, and the Bass in F. But experience shows that the alto and bass are very seldom forthcoming, the tenor trombone being that most frequently met with in this country. Their compass is shown in Ex. **33** (alto), **34** (tenor), **35** (bass). For some entirely inexplicable reason the trombones are not considered as transposing instruments, but the actual notes are written. It is usual to write for two tenor and a bass trombone for the concert orchestra, although, as before explained, the latter will probably be substituted by a third tenor trombone.

Despite their immense power when playing *forte* the trombones have a considerable range of tone, and their *pianissimo* is very beautiful and dignified.

It will be seen that the slide of the trombone is less adapted to quick passages than the valve mechanism, but the trombone would be unsuited to rapid movement, as its tone is heavy and slow-speaking.

The Saxhorns, or Tubas. These instruments are similar in construction and effect to the cornet. They are made in seven sizes, and are mostly written as transposing instruments. The four highest are used only in military bands, and need not be considered here. The remaining three are these:

The Bass Tuba in B♭, called also the Euphonium [Ex. **36**].
The Bombardon, or Bass Tuba in E♭ [Ex. **37**].
The Contrabass Tuba in B♭ [Ex. **38**].

The compass given is for the best part of the instrument, but some lower notes can be obtained,

especially on the highest of the three, and occasionally a few notes above the written G.

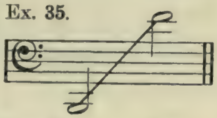
The B♭ bass tuba, or euphonium, is the instrument most generally used to form the bass of the trombone harmony in the concert orchestra. On these occasions composers have, for no particular reason, abolished transpositions, and written the actual sounds for this instrument. The remaining brass instruments may be ignored by the student for some time to come. If he can acquire a knowledge of those described in these pages, he will have cleared away much of the confusion that always surrounds this subject in the mind of the beginner.

INSTRUMENTS OF PERCUSSION

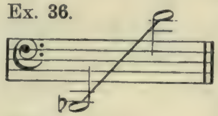
This, the fourth group of instruments, need not detain us long. The majority of them have but limited capabilities, and need to be used with extreme reticence. We will briefly describe the following: timpani, bass drum, side-drum, cymbals, triangle, tam-tam, bells and carillon. There are many others, but not of very great importance.

The Timpani, or Kettle-drums. These instruments enjoy the distinction of being the only variety of drum producing a musical note of definite pitch. In construction they consist of a hemispherical body of copper, the open end covered with vellum which can be strained more or less tightly by means of screws placed round the circumference, thus giving notes of varying pitch. There are usually two or three in an orchestra; the compass of the largest is given in Ex. **39**, and of the smallest in Ex. **40**. If there is a third drum, it is usually of medium size. The drums are played with a pair of light, elastic sticks with a head of felt or rubber. When used very rapidly alternately, the effect produced is called a roll. It is written as shown in Ex. **41**. It has almost the effect of a continuous sound, and is equally effective in *piano* or *forte*. It will be obvious that each drum can only play one note (unless a change of tuning is effected, a process requiring some little time). They should, therefore, be tuned at starting to the notes most wanted during the composition. The older composers most naturally required the tonic and dominant of the key, but this is by no means always the case with modern music. If a change of tuning is required in the middle of a work a sufficient number of bars rest (some 20 or 30 seconds) must be allowed to effect this, and the indication written, "Muta — in —" naming the original note and the fresh one required. If the student desires to know how to write effectively for the timpani, let him study the scores of Beethoven's symphonies, notably Nos. 4 and 9, and he will understand how its limitations can be turned to account in the hands of a great composer.

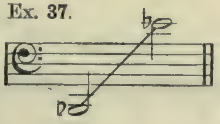
Ex. 35.



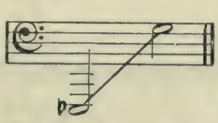
Ex. 36.



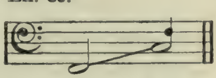
Ex. 37.



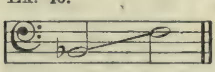
Ex. 38.



Ex. 39.



Ex. 40.



The effect of double notes on the drums (one stick to each drum) has been tried, but it is not particularly effective, and Berlioz's directions requiring sixteen drums whereby full chords are to be played are most certainly not worth the trouble. It is possible to mute the kettle-drum by laying a cloth on the drumhead, but the effect is little used.

Quite recently a pair of chromatic drums have been introduced in London; they are provided with mechanism enabling them to be tuned instantly to any note. This should prove a great convenience.

The Bass Drum. The bass drum is an instrument familiar to everybody. If properly made it should produce a sound of indefinite pitch. It should be used with great reticence, and not be permitted to degenerate into a mere noise-maker. A stroke *pianissimo* can at times be used with beautiful effect, and the roll, which is preferably played with timpani sticks, is occasionally useful.

The Cymbals. The bass drum is often associated with the cymbals. These are circular plates of hammered brass, which are clashed together, and are capable of producing a sonorous, metallic clang that is impressive if rightly employed. In theatre bands (particularly during the pantomime season) one cymbal is fixed to the bass drum, and the player wields the other with his left hand while with the right he holds the drumstick, and with these two instruments he punctuates the first of every bar. This inartistic treatment is only fitted for circus music and the like, and should be severely discouraged by the musician.

A charming effect may sometimes be had by playing the cymbals *pianissimo* [see the 7th No. of Tschaikowski's Casse - Noisette Suite, which is a revelation of what may be done with percussion instruments]. A roll on a cymbal, performed with a pair of drumsticks, produces a very weird and sinister effect; or the cymbal may be hit with the stick.

The Side-drum. The side-drum is not often required, except to impart a military flavour to music. It is chiefly employed for the roll, which is of thrilling effect, and has a range of tone from *ppp* to *fff*.

The Triangle. The triangle is a rod of hard steel, bent in the form of a triangle. It is struck with a short steel rod, and emits a clear, bell-like note, which should have no definite pitch. Its occasional use has the effect of brightening up the music; but, as with all percussion instruments, it must be sparingly employed.

Tam-tam. Mention may be made of the tam-tam, or gong, which is still more rarely used, and the various devices for imitating bells.

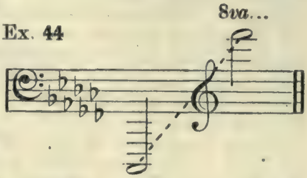
The deep tone of a church bell is very accurately reproduced by means of steel tubes, which are suspended and hit with a mallet.

Glockenspiel. For a higher pitched instrument with a clear, bell-like tone, the glockenspiel or carillon is employed. This instrument consists of a series of steel bars suspended in a frame, and hit with light wooden hammers. A large number of these bars can be obtained [Ex. 43], so that it is possible to play a complete melody on this instrument, although it is not often advisable to do so. Its effectiveness would seem to be in inverse ratio to the frequency of its employment.

Ex. 41.

The Celesta. A somewhat similar instrument, though with a far purer and more liquid tone, is the celesta. This is furnished with a keyboard like a small pianoforte, so that chords and rapid passages are quite within its capacity, and are most effective besides. Its compass is given in Ex. 42. One of the most notable examples of the use of this instrument is in the 3rd No. of Tschaikowski's Casse-Noisette Suite, before mentioned

Ex. 44



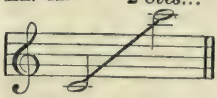
Of the miscellaneous instruments not included in any of the preceding groups, the only one of importance is the harp.

Ex. 45.

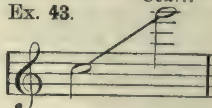
The Harp. This instrument has its strings tuned to the diatonic scale of C ♭, its 48 strings producing the notes between the following extremes shown in Ex. 44. A series of seven pedals in the base of the harp is connected with an ingenious mechanism, whereby, on depressing one pedal, all the A ♭ strings are raised a semitone to A ♮, and can be retained so as long as desired. On still further depressing the pedal, they are converted into A ♯. The remaining pedals perform the same operations for the other degrees of the scale. It will thus be seen that a chromatic scale can only be played as fast as it is possible to depress the pedals, and this "footwork" is rather slow and clumsy, so that many of the passages written by Wagner in "Die Walküre" and elsewhere are practically impossible.

On the other hand, diatonic music is equally easy in any key, and especially wide-spread arpeggios, which no other orchestral instrument can play satisfactorily, are just what the harp can best undertake. Two effects peculiar

Ex. 42.



Ex. 43.



to the harp deserve mention. If the pedals are arranged C, D ♯, E ♭, F ♯, G ♭, A, B ♯, and the finger drawn rapidly across the strings in the manner called *glissando*, the effect on the ear will be as of a very rapid and evenly executed arpeggio of the diminished seventh [Ex. 45]. All diminished sevenths, and some other chords, which the student can ascertain for himself, can be played thus *glissando*, and the effect is very striking. Another interesting effect is that of harmonics. By lightly touching any string in the middle it can be made to sound an octave higher, and with a curiously altered tone. This should be indicated in the music by a little circle (°) over the notes to be thus played.

It must be observed that the tone of the harp is never strong, and is easily overpowered by the orchestra; especially is this the case when playing in its lower octaves. This smothering of the harp is the prevailing fault of German composers, and one must turn to France to find really effective harp writing.

The *Pianoforte* and the *Organ* are so rarely used as orchestral instruments that it is not necessary to do more than mention them.

Continued

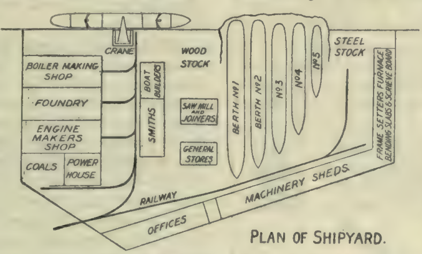
WORK IN THE SHIPYARD

General Arrangement of the Shipyard. Laying the Keel. Making the Frame

continued from page 5619

By Dr. J. BRUHN

Position of Shipyards. Many points have to be considered in deciding upon the most suitable situation of a large shipyard. In order that a yard may possess a high degree of efficiency it is necessary that it should be within ready access of the chief raw material used in the production of ships—namely, iron or steel. It is also desirable that a convenient supply of coal should be at hand. The transport of these items forms no small part of the cost of a ship, and the yard which is far removed from the source of supply of these necessities is at a great disadvantage compared with those nearer. Not only are the direct transit expenses heavier, but there is additional chance of delay in delivery, and delay means expense. The ideal situation of a shipyard is therefore in the midst of an iron and coal producing locality. Failing this, the next best arrangement is to lay down the yard at a place where there is cheap transit facilities—say, by sea—to the source of the raw materials. Another very important consideration in connection with the selection of a situation for a shipyard is the adequate supply of labour. To a certain extent this can be arranged for at any place, but it has its great advantages to select a locality where there is already a good supply of labour. A yard for the building of large ships must necessarily be situated near the sea, for preference at some sheltered bay or river, where there is a suitable depth of water to launch the vessel, and where the shore is of a sufficiently firm character to carry the heavy weight of the hulls without expensive piling. The exact places in the yards where the ships are built are called *berths*, and in a large yard there may be as many as a dozen of these. Round the berths are situated the offices and sheds, with all the necessary machinery and stores. The exact general arrangement of a shipyard varies very much according to the circumstances of each individual case, but in the laying out of a new yard the aim should always be to save all unnecessary transference of material or men. In such extensive establishments as shipyards a large amount of continuous expense may easily be incurred by inconvenient arrangements of sheds and machinery, which may necessitate extra handling of the material or the wasting of time by the men in getting from one place to another.



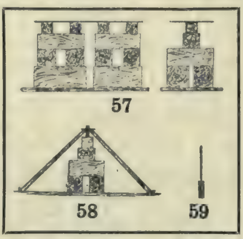
56. ARRANGEMENT OF A SHIPYARD

General Arrangement of a Shipyard. Figure **56** indicates the general arrangement of a shipyard. All the head offices are at the entrance. In the centre of the yard to the right are the building berths, and round them are situated all the iron and wood workers' sheds and machinery. On the extreme right are the frame setters' furnaces, with the bending slabs and the scrieve boards. Just outside these is the stock of steel plates and angles, which can be fed both from steamers at the adjoining quay and from the railway which runs into the yard. At the head of the berths are the sheds containing all the machinery for the cold manipulation of the steel plates and angles. Light rails are usually laid down in the yard, and small trucks provided for the conveyance of the material from machine to machine or to the ship. In some instances nearly all the transference is done by means of cranes or overhead trolleys working on stretched wire ropes, the object being in each case the saving of time and manual labour. Immediately to the left of the building berths are the sawmills, with the joiners' and cabinetmakers' shops above, and the stock of wood in front, where it can be readily landed from the timber ships. Near the centre of the yard are the general stores, where all the smaller items constantly being used in the construction of ships are kept. At the extreme left of the yard are the engine and boilermakers' shops, the foundry, and the power-house, from the last of which the necessary energy for driving all the yard machinery is obtained. The engine and boiler shops and the foundry communicate with each other by rails as well as with the powerful crane at the quay side, where the ships lie after being launched and receive their machinery and other outfit. Opposite the boiler and engine shops are the smiths' and boatbuilders' sheds. Many shipyards are not so complete as the one here described. In some there are only the necessary appliances for the building of the ships proper, and the engines, boilers, and other secondary parts of a ship are made elsewhere. In nearly all shipyards the majority of the items that go to make up a modern ship's outfit, such as auxiliary engines, boats, etc., are made elsewhere, where they can be manufactured on a more extensive scale, and therefore more cheaply.

Keel Blocks. While the ship is taking shape in the drawing office the yard outside is being prepared for the beginning of the actual building operations. In the first instance, it is necessary to see that the ground is so firm that it will not yield at any place under the heavy weight of the hull. If it did do so it would have serious consequences, as it would be sure to cause the huge steel structure to be deformed. The ground of the building berths slopes gradually towards the water at a rate of about one in forty or fifty, and when the foundation is secure and the space cleared of obstructions the keel blocks can be laid. These consist of piles of wooden blocks as shown in **57**. They are built up in a row from the water edge up the building berth as far as the vessel will extend. In order to distribute the pressure of the blocks on the ground,

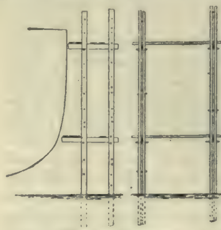
it is usual to begin by laying a few rows of planks and then to build on the top of these—a couple of blocks of wood being first laid in the one direction and then a couple in the other in order to give sufficient stability. As the piles get higher, the size of the blocks is reduced, and when the required height has been reached a small cubical block is placed on the top as shown in **57**. Great care must be taken that all these blocks are exactly in line both horizontally and vertically. If the piles were all of the same height, the line of the top blocks would have the same slope as the ground, but it is usual to give the keel of the vessel a little more slope than the ground, in which case the piles get gradually higher as the fore end of the vessel is approached. Careful attention is paid by the carpenters to these piles during the earlier stages of the building operations, as almost the entire weight of the structure is then borne by these supports. Later on similar piles, called *bilge blocks*, are provided at the side under the flat of the bottom to take part of the weight in addition to balancing the structure on the centre row of keel blocks. When the latter supports are ready, the keel bar or plate can be laid.

Laying of the Keel. Nearly all modern ships have what is called a *flat keel plate*, which is simply a strake of steel plating like all the remainder of the bottom but usually a little thicker. The preparation of such a keel is a comparatively simple question—at least, for the greater part of the vessel's length, where it is usually of parallel width and perfectly flat. The keel plate varies in thickness from about $\frac{1}{2}$ in. in the smaller vessels to $1\frac{1}{4}$ in. in the largest, and in width from 2 to 5 ft. The plates are ordered practically to the neat sizes, so that they have only to be straightened by being passed through the rollers, planed on the edges, and punched according to templates for the rivets they have to receive. They can then be laid on the blocks and sighted to ensure that they are all in line vertically and horizontally. The laying of an ordinary bar keel is equally simple. Little pieces of wood are nailed to the top keel block to form a slot for the reception of the keel bars. These consist of wrought-iron bars from 3 in. by $\frac{1}{2}$ in. to 12 in. by 4 in., according to the size of the vessel. They are connected by scarfs, but only a few rivets are needed to hold them together, as the plating of the garboard strakes will, when in position, form efficient straps on both sides of the scarfs. The bars are straightened, and holes are drilled in them before they are placed in position—the exact position of the holes being obtained from templates. When the individual bars have been placed in position and attached, the entire keel is sighted and secured more firmly laterally by sloping shores from the ground as shown by **58**. Besides the plain bar keel there are other more complex forms of keels, such as the side-bar keel, shown in **59**, which is formed of two thinner bars fitted one on each side of a vertical plate, which extends up into the ship for the depth of the floors or more. This form is dealt with as an ordinary bar keel, but it is, however, rarely adopted now. The laying of the keel is an act which shipbuilders often proceed with without delay, as the first instalment of the price of the ship is then usually paid them by the prospective owners. While the keel is being prepared and laid, poles for staging may be erected by the carpenters.



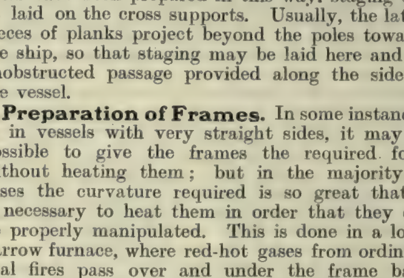
57. Keel blocks **58.** Keel supports **59.** Side bar keel

Staging. A sketch of the uppermost deck plan is supplied by the drawing office and the stage poles are arranged to be sufficiently clear of the vessel at all points to admit of all working operations, principally that of riveting, being carried on without hindrance. The ordinary stage poles consist of two rough pieces of timber obtained by sawing a pine trunk through the middle. They are then brought apart a distance of about 3 in., as shown in **60**, and held in that position by short pieces of plank and bolts. They are let into the ground a sufficient distance to keep them upright without other support. Cross pieces of planks, called *thwarts*, are then placed on edge in the intermediate spaces and supported by iron bolts inserted, at the required height, through one of the numerous holes provided for the purpose. When two pairs of poles have been prepared in this way, staging can be laid on the cross supports. Usually, the latter pieces of planks project beyond the poles towards the ship, so that staging may be laid here and an unobstructed passage provided along the side of the vessel.



60. STAGING

Preparation of Frames. In some instances, as in vessels with very straight sides, it may be possible to give the frames the required form without heating them; but in the majority of cases the curvature required is so great that it is necessary to heat them in order that they can be properly manipulated. This is done in a long, narrow furnace, where red-hot gases from ordinary coal fires pass over and under the frame bars. The furnace is designed with a view to the temperature being as nearly as possible uniform throughout, as it is very important that the long bars should be heated equally throughout their length, so that they may be made hot enough at all points without the metal being burned at any place. Immediately in front of the furnace door are the bending slabs, which consist of a floor of heavy blocks of cast iron about 6 in. thick, and perforated by numerous holes about $1\frac{1}{2}$ in. in diameter, as shown in **61**.



61. BENDING SLABS

This floor must always be close to the scrieve board, described in the preceding article [see page 5316].

The operation of preparing the frames is as follows: A considerable number of rivet holes are, of course, necessary in a frame, and as it is easier to punch these when the bar is straight than when bent, it follows that punching is the first operation to which the bar must be subjected after being obtained from the stock, and having had its dimensions checked. It would be desirable to punch all holes at this stage, but where the curvature is great this is not possible, as the process of bending distorts the holes too much at such places; when the material stretches the holes elongate, and when it contracts they become compressed. At such places the holes are, therefore, not punched until the bar is bent. This applies to the holes in the neighbourhood of the bilge, where there is nearly always a considerable amount of curvature. The marking of the frame rivet holes for the outside plating is made by means of a flexible batten, which is bent round to the line of the particular frame on the scrieve board. The positions where the landing edges cross the frames are marked in chalk on the batten, as is also the exact length of the frame. The batten is then allowed to spring straight and laid on the bar in such a way that there is a little to spare in the length at each end, which is allowed for in ordering the bar, and which is convenient in the subsequent bending operation. The positions of the landing edges are then indicated on the bar, and the marking of the rivet holes in the shell flange, or the flange attached to the outside or shell plating can be made.

Punching of Frames. The spacing of the rivets centre to centre is stated in a sketch of the framing of the vessel, which is supplied to the workmen by the drawing office. The rivets attaching two adjoining strakes of plating will, in way of a frame, also pass through it. Their position must be governed by the landing edge, which is not known exactly in relation to the frame, and it follows that there would be a considerable chance of unsatisfactory fitting if the shell edge or landing rivet holes in the frame bars were punched at this stage of the work. In marking the bars the spaces in way of the landings are, therefore, left blank, the holes being "beared" or punched by hand when the frames are erected in their proper place in the vessel, and when the exact position of the landing edges have been marked by means of fairing battens passed through the guide spots provided by the above-mentioned marks obtained from the scrieve board. If a reversed frame is to be fitted, the holes for the rivets attaching it to the frame must be marked on the athwartship flange of the latter, according to the spacing given on framing sketch.

Here, again, blank spaces are left in way of beam knees and lugs attaching stringers to frames, in order that these holes may be marked more exactly at a later moment. When all the required holes and the exact length of the frame have been marked, the bar is taken to be punched. This is done by means of a powerful machine, driven by mechanical power. The bar is laid on a strong bolster with a hole in it, a little larger in diameter than the required rivet hole. A strong die of the size of the rivet is then applied with great pressure above, as shown in **62**, with the result that a circular portion of the material of the bar is forced through the bolster below, and a rivet hole thus provided in the frame. This is the usual way of making holes in ship construction, except where very great accuracy is desirable, when the holes are made by the much more tedious and expensive process of drilling. With experienced workmen a punching machine may be kept going at a considerable speed, holes being made as fast as the bar can be passed carefully through the machine. When a number of frame bars have been punched, and have had their exact lengths permanently nicked with a chisel, they are placed in the above-mentioned furnace for heating.

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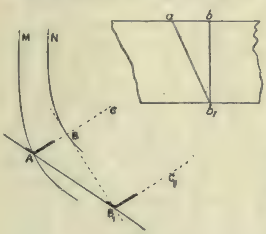
Form of Frame Angles. The next operation which the frame bars are subjected to is that of bevelling. The athwartship flange of frames are always in a transverse plane at right angles to the keel line. Where the bottom and side of the vessel are cylindrical, as it may be for some considerable distance amidships, the outside or shell plating, and consequently the shell flange of the frames, will be at right angles to the transverse flange. Nearer the ends of the vessel, where the shell plating is curved in a fore-and-aft direction, the shell flange will no longer be at right angles to the transverse one, and as rolled steel bars are always delivered from the steel works with their flanges at right angles to each other it follows that frames at the ends of vessels must have that angle modified along their length to suit the angle which the shell plating makes with transverse plane of the frame. It is this operation which is called *bevelling*. The amount of bevel to be given to a frame is measured on the scrieve board in the following simple manner: Let AM and BN [**63**] represent the lines of two consecutive frames, and let AC represent a fore-and-aft plane at right angles to the planes of the frames. Between the frames considered the shell has curved inwards to the extent of AB. The fore-and-aft spacing of the planes of the frames or of the lines AM and BN is simply the frame spacing, and if BB_1 is drawn equal to this, it follows that AC may be taken to be a plan view of the frame AM, and B_1C_1 the same view of the frame BN. AB_1 will then represent the line of the shell plating between these frames, and AB_1C_1 is the angle between the plane of the frame BN and the outside plating or the angle to which the frame has to be bevelled. A board equal in width to the spacing of the frames may be obtained and a line bb_1 [**63**] may be drawn across it at right angles to the edges. If ba is set off equal to AB, the normal distance between two frame lines, as shown on the scrieve board, it follows that ab_1b is the angle required. In this way the bevel may be measured at any point of the length of the frame and recorded on a piece of board. A simple mechanism which can be adjusted to suit the frame spacing is usually employed in measuring bevels directly on the scrieve boards.



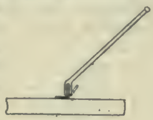
63

Bevelling of Frames. When the frame bar is heated sufficiently it is pulled out of the furnace on to the bending slabs, where it is laid straight, and one flange is held down by means of a piece of set iron along the edge, and a number of appliances called *dogs*. These

latter consist simply of iron bars bent to an angle, as shown by **64**. By placing one arm in one of the holes in the bending slab and hammering it down securely a considerable pressure may be applied by the other end on the slab or anything on it.

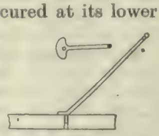
64

A few of these dogs can thus hold a plate or angle iron very tightly to the bending slabs. When the frame bar is securely fixed a bevelling lever is applied to the vertical flange, as shown by **65**, and the angle of the bar is opened at the various points of the length previously marked, and to the extent indicated by the record of bevels taken from the scrieve board. Hammers are also used in the process of angling the vertical flange, as unevennesses can be removed by a few strokes while the bar is hot. In some instances the process of bevelling is done by a machine, which operates on the bar as it is withdrawn from the furnace, a simple lever movement effecting the necessary adjustment in the bevel, and indicating at the same time automatically the amount of bevel that is being given to the bar. The bevelling of a frame bar need not be done with special care as it has to be done over again, or, at any rate, carefully checked during the process of bending. Preparatory to this the bar is again placed in the furnace, and while it is being re-heated the workmen prepare the bending slabs.



65

The Bending of Frames. First they mark carefully on the scrieve board the line of the frame about to be bent. Then they take a piece of thin iron, called a *set iron*, which is readily bent to the shape of the frame line. It is then laid on the bending slabs, and a chalk line drawn on same, which is the line of the frame transferred by the set iron from the scrieve board. It indicates the final shape of the frame, but if the bar was bent exactly to it the result would be that it would not get curvature enough, as it straightens considerably in the process of cooling. The experienced frame-setter knows how much more curvature it is necessary to give to the set iron in order that the frame may have the proper curvature when cool. When the set iron has been given this extra curvature it is laid on the iron slabs, to form a mould against which the frame may be bent. To retain it firmly in the position, dogs are again used. In order that the set iron may be able to resist the pressure of the heavy blows on the frame bar when it is being bent it is necessary to drive stout iron pins into the floor holes close against the concave side of the set iron. In many cases it will be found that it is impossible to drive a pin into a hole, and having it bearing tightly against the side of the set iron; and it is therefore necessary to place wedges or rings of suitable thickness against or round the pins in order to obtain a proper backing against which to work. When all this has been done and the frame bar is heated to nearly a white heat, it is drawn out of the furnace and rapidly placed in position and secured at its lower end. If it is a light bar it can now be bent round the set iron mould by means of a chain fixed at the other end. If the bar is a heavy one, it is convenient to use a squeezer to press it home to the mould.



66

This is simply a lever, as shown by **66**, adapted to the circumstances with a tap fitting in the holes in the bending slabs. In this way great gradual pressure can be applied rapidly at any place where it may be required. At certain places a few smart blows from a hammer may be necessary to make the bar fit close to the mould at all points. In the process of bending, the horizontal flange of the frame will usually become uneven, and it becomes necessary to adjust such irregularities before the bar cools too much. This is done by means of blows from large, flat-headed hammers, or blows on the top of a flattener held on the unevennesses. While the bar is still hot the bevel previously given to the frame is carefully checked all along and rectified where found incorrect. It is highly important, in order to ensure high-class workmanship, that the bevelling is carefully done, and that the shell flange is quite fair and smooth, as otherwise it will be found impossible later on to obtain a fair fitting surface for the outside plating.

Reversed Frames. The hold ceiling of a vessel is fixed to the reversed frames, and the holes required for this purpose may be punched before the bar is bent, but sometimes they are punched by hand or "beared" when the ceiling is being fitted. If the punching is done before bending, the position of the ceiling planks or cargo battens is given, and the holes are marked and punched accordingly. The reversed bar is then bevelled and bent in the same manner as a frame bar, but as it is most convenient to have the set iron adapted to the concave side of the bar, it follows that this mould will, in the case of frames, be fixed on the bending slabs to the toe of the frame flange and to the heel of the reversed frame bar. Bulb angle and channel frames are bent as ordinary angle bars, but when Z frames are adopted it is necessary to use special iron blocks laid on the bending slabs to raise the web of the bar sufficiently to allow of the frame being bent without its canting through one of its flanges touching the ground. When a frame and reversed frame for one side of the vessel have been bent, their respective set iron moulds are simply reversed on the bending slabs, and the corresponding angles for the other side of the vessel can be bent at once. The floor plates are now very rarely bent in steamers. It is only where narrow floors are adopted in single-bottom vessels that the floor plates are bent at the bilges. They may be bent on the slabs to the same line as the frames, or the bend may be of such a local character that the work is done by the ordinary smiths, who are supplied with templates, giving the required form of the floors at the bilge. As these plates are fitted between the frames and reversed frame angles, the extreme point is hammered down to give it a wedge-shaped form, which will admit of the frame and reversed frame being gradually brought close together, without the use of wedge-shaped packing pieces to fill the otherwise empty interstices. In most modern ships the floor plates which are directly attached to the main frames are simply brackets that are sheared cold to their proper shape.

Checking the Curvature of Frames. When the frame and reversed frame have cooled sufficiently they are taken to the scrieve board and their form checked with the proper frame line. Any little discrepancies that may be observed now are easily adjusted without re-heating the bar. The curvature is modified by simply holding two very heavy hammers against the bar

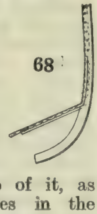
a little distance apart, and then striking it heavily with a third midway between the two. When the exact required form has been obtained the bar is laid on the scrieve board in its proper place and the correct position of decks, stringers, ribbands, landings, etc., are permanently marked in a manner that will admit of easy identification later on. The exact length of the frame is also marked now, as well as the rivet holes for stringer lugs and beam knees, and for the shell plating at the bilge, where they were omitted until now, when greater accuracy can be ensured. The frame is then sheared to its exact length, and the required holes are punched. When the frame bar corresponding to a line on the scrieve board has been dealt with in this manner, it is laid on the ground and the corresponding frame for the other side of the vessel, which cannot be checked by the scrieved line, is reversed and laid on the top of the frame already dealt with, in order that their curvature may be made to agree exactly. The position of decks, stringers, ribbands and landings, and rivet holes that require to be punched, are marked to agree with those of the other bar.

The rivet holes required for the beam knees and for side stringer lugs are usually marked by templates which are exact wooden copies of part of the beam knees and of the short angles attaching stringers to frames where there are no reversed frames, or in conjunction with these bars. The rivet holes required in the knees and lugs are drilled in the wood pattern, which is simply laid in its proper position on the frame, and the holes marked on same with paint, through those in the board.

Floor Plates. When a frame has been sheared and punched, the corresponding floor end bracket is laid in its proper position on the scrieve board, and the frame is placed on the top of it, as shown in **67**. The required shape of the floor plate is obtained by drawing a chalk line on it along the heel of the frame. The upper edge is usually straight, in which case one of the edges of the plate is made to coincide with this line. The holes for the rivets attaching the frame to the floor brackets are already punched in the former, and as the frame is lying on the top of the floor plate, the holes are easily transferred to the latter by paint marks. The remainder of the holes in the floor brackets—namely, those for the attachment to the tank margin plate, and to the reversed frame, may be marked from templates, or in the latter instance, from a piece of set iron bent to the shape of the lower part of the reversed frame, and laid on the frame and floor plate in lieu of the reversed angle, which has not been completely prepared at this stage. The floor bracket can now be sheared and punched, and is then complete.

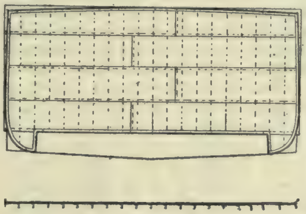
67

68



A bent reversed frame must, in the first instance, have its curvature checked by being laid on the frame, with which it is made to agree. When this is done, it is laid on the ground, and the frame is placed in the top of it, as indicated by **68**, when all the holes in the transverse flange of the frame are readily transferred to the reversed frame by paint marks. The holes for the floor rivets are marked on the reversed frame by the piece of set iron used in marking the floor plates, care being taken to ensure it being in the same exact relative position with regard to the frames as when the floor plate was being marked. When the reversed frame has been sheared and punched, the three parts—namely, the frame, reversed frame, and floor bracket, can at once be brought near to the building berth and bolted together ready for riveting. The processes of punching, bevelling, and bending the frames and reversed frames, checking their curvature, shearing and punching the floor plates, and fitting them all together, are usually being carried on simultaneously by various squads or gangs of men.

Watertight Bulkheads. The bulkhead frames are usually dealt with separately, although in the same manner as the ordinary frames. No reversed bar is required here, but double frames are commonly fitted. When the frames for a watertight bulkhead have been bevelled, bent, and checked, the entire bulkhead plating is laid on the scrieve board in the proper position, and with proper overlaps, as indicated on the bulkhead plan supplied by the drawing office ; and the frames, or at least one set, if they are double, are laid on the top also in the proper relative position, as shown by **69**. An outline of the bulkhead can then be drawn in chalk along the heel of the frame bar, and the rivet holes already punched in the frame angles can be transferred to the plating. These holes must be much closer spaced than the rivets in the frames and reversed frames, as the work is to be watertight at this place. The rivet holes in the edges and butts of the uppermost alternate strakes of plating, as they lie on the scrieve board, have previously been marked and punched. They are simply marked at their proper spacing and proper distance from the edge, as stated on the plan. The corresponding rivet holes for the strakes of plating below are then simply marked through those of the plates above. The work of fitting the bulkhead plating is comparatively simple, as nearly all the plates are parallel, and require no shearing, except, perhaps, on one end or edge, where it is at the boundary of the bulkhead. The top bar or bars attaching the bulkhead to the deck plating are bent cold to the curve of the deck in the manner of beams, as will be described later on. The rivet holes in this angle are transferred to the bulkhead plating, as in the case of the frames. The bulkhead stiffeners are shown on the plan, and the rivet holes for their attachment to the plating are marked as specified on the drawing, and punched accordingly. The bars may then be laid in their proper position on the bulkhead on the scrieve board, and the holes can be transferred to the plates, which are then ready for punching and shearing to shape. Bulkhead stiffeners are now commonly formed by fitting the plates vertically, of suitable width, and flanging one end of each plate, or both edges of alternate plates, by which arrangement a considerable amount of weight and expense is saved, as fewer pieces of material are required, and also less riveting. Another common device of reducing the expense is to fit single frame and deck angles, in which case they are, however, usually of increased size.



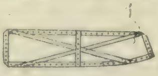
69. WATER-TIGHT BULKHEAD

Double-bottom Frames, Reversed Frames, and Floors. The frames of the double bottom are, as a rule, simply small angles with flanges of equal width attaching the shell plates to the floor plates. In some instances, they are perfectly straight for the greater part of the vessel's length amidships, as indicated in **70**, in which case they may even be entirely dispensed with through flanging the floor plate at the lower edge. Where, as is usually the case, there is a slight bend in the frame at the outer end, one pattern or template will serve for a great number of frames, although the length of the bars may shorten as the ends of the vessel are approached. The templates not only give the form of the frame, but also the position of the rivet holes, both for the attachments to the shell plating and to the floor plates. The templates consist, in fact, of two exact but separate wood patterns of the two flanges of the frames. When the length of the bar, the rivet holes, and the landing edges have been marked, the angle can be sheared and punched. It is then heated, if required, and bent in the usual manner on the scrieve board, where one piece of set iron will serve for the majority of the frames, owing to the bottom being flat, except for the rise of floor for the greater portion of its length. The frames of the ends of double bottoms where the curvature varies are dealt with as ordinary frames from the lines on the scrieve board. The reversed frames of double bottoms are usually perfectly straight and without bevel for the entire length of the inner bottom. They can, therefore, be dealt with throughout by template, as in the case of the amidship frames. They are very commonly dispensed with by flanging the upper edge of the floor plates to form an attachment to the inner bottom. The floor plates of an inner bottom are almost entirely dealt with by templates.

70

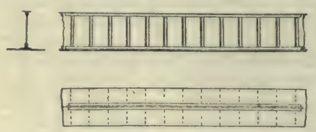
Templates. These appliances have already been referred to more than once. As they are very commonly used in ship construction, they may conveniently be explained somewhat more fully here. They are, as the word implies, temporary plates, which serve as patterns for the real ones. They are made of very thin and light strips of boards, nailed together to the required form. If this should not be made up of straight lines, it is approximately roughed out by pieces of boards, and the exact form can then be easily cut in the thin wood with a knife. These patterns can be conveniently carried about, and more exact workmanship is, in fact, possible with them, owing to their handiness, than if the actual plates were being used for the purpose.

Figure **71** shows such a template for the floor plates of a double bottom. The exact outline of the floor is first produced. Next rivet holes for the attachment of the frames, reversed frames, and centre, side and tank margin girders are marked according to their specified spacing. When a plate has been obtained from the stock the template is laid on the top of it, and the exact shape of the floor as well as all the rivet holes can be marked in a very short time. The plate is then ready for being sheared and punched. The template above referred to for the transverse flange of the frame of a double bottom is simply an exact replica of the lower edge of the floor template. Similarly the template for the transverse flange of the reversed frame is a replica of the upper edge of the floor. When the floor plates and the frames and reversed frames of a double bottom have been prepared, the various items are bolted together and riveted up in the neighbourhood of the building berth ready for erection.



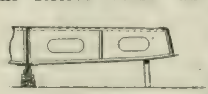
71

Erection of Centre Girder. The laying of the keel has already been described. When it is a flat plate keel, each plate is prepared from a template which shows the rivet holes in the edges, butts, frames and centre girder or keel angles indicated in **72**. One template will serve for the great majority of the plates. When the keel plates have been laid, secured and sighted, they are bolted together, and the work of erecting the centre girder may be proceeded with at once. The keel angles are first fitted. The rivet holes in the horizontal flanges are marked from templates corresponding to the centre rows of rivets in the keel plates. The holes in the vertical flanges are likewise marked from a template. When the angles are sheared and punched, they are placed in position, and screwed down with bolts and nuts. The vertical keel plates are now prepared. For the bottom rows of rivets the template is the same as was used for the vertical flange of the keel angles. At the upper edge a fresh template is used for the holes of the centre girder top angles. A short template is prepared for the vertical angles attaching the floor plates to the centre girder, one template serving for all. The position of each floor must be carefully marked on the centre girder plate before the templates are applied. The holes in the vertical flanges of the top angles of the girder are marked from templates as in the case of the keel angles, and those in the horizontal flanges for the attachment to the tank top plating may be marked either from templates or simply in accordance with a specified spacing. When the flat and vertical keel plates and angles have been erected and securely bolted they are all riveted up together and the first part of the ship is complete. Usually the vertical angles on the centre girder are prepared and riveted up at the same time as the remainder of the girder.



72. CENTRE GIRDER

Erection of Floor Plates and Side Girders. As soon as the centre girder is completed the erection of the floors is proceeded with. This is a very simple piece of work, as it is only necessary to lift them to the required height, bolt them to the vertical angles on the centre girder at the one end, and fit a ribband with shores to the ground as support at the other end. A ribband is a straight or bent timber, usually of nearly square section, which is employed temporarily to secure floors, frames, and beams in their proper relative position until the plating serves this purpose. Their positions have to be arranged to suit the fitting of the plating, and they are consequently marked on the scrieve board and transferred to all the frames. The erection of the floors may take place concurrently with others being riveted up on the ground, and as the work of erection proceeds the

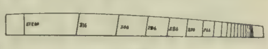


73

intercostal girders shown in **70** and **73** may also be fitted in place. They consist of plain rectangular pieces of plates that may be made to templates, if they are not ordered from the steel works to exact size, or, these plates being small, they may be taken to the ship, and the vertical rows of holes marked to suit those in the angles already riveted to the floor plates. The prompt fitting of these intercostal plates is very desirable, as they add rigidity to the structure, and prevent the floor plates from tripping. When the floors are erected the fitting of the margin plate may be proceeded with. Figure **73** shows a common arrangement of the termination of the double bottom. The margin plate consists here of a continuous girder similar to the one at the centre line, but shallower, and fitted at an angle to the vertical in order to be square to the surface of the ship. At the bottom edge it is attached to the shell plating by a single angle, and at the upper edge it is flanged to form part of the tank top plating, to which it is, of course, attached. The plates are prepared from templates adjusted and marked in position on the floors. The margin angle for attachment to the shell plating is prepared when the plate is completed and in position, the rivet holes being transferred by template. The flanging at the upper part of the margin plate is usually done cold, as in the case of flanged floor plates. The plate is rigidly secured in a flanging machine, as shown in **74**, while a roller is forcing part of it downwards until it is at right angles to the remainder. When the floor plates have been secured in position the inner bottom may be plated at once, or this may be left until the outside bottom is plated. In any case the work is done by templates similar to that of the shell plating, which will be described in detail later on. As the bottom is practically horizontal, and as the edges of the plates are usually straight, the work is fairly simple.

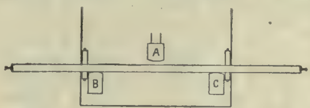
74

Preparation of Beams. The upper decks of ships are usually curved upwards amidships, to allow for the drainage of water. The lower decks may be flat, but as a rule they also are curved. The bending of the beams to acquire this curvature is, however, a very simple affair compared with the bending of the frames. In the first instance the curvature is so small that the beams can always be bent cold, and, in the second instance, the curvature is uniform, so that one mould will serve for all the beams of a ship. A beam plan is supplied by the drawing office, showing the exact position and length of each beam, and the amount of plating or planking to be fitted on it. The workmen are further provided with a beam mould as shown by **75**. This is a wood board with one edge straight and the other cut to the exact required curve of the deck, which is usually supposed to be part of a circle or parabola. The correct lines of the frames are indicated on the mould, and they show therefore the length of the beams. Various rolled sections are adopted for beams such as bulb tee, bulb angle, channel bar, bulb plate and angles, etc., but the preparation of all of them is similar. When a beam bar has been obtained by the workmen, and its identification marks found to agree with those on the plan, it is marked for cutting and punching. The length is obtained by bending a flexible batten round the mould and marking the breadth of the vessel at the particular frame section. Usually only half breadths are given, in which case the centre of the beam bar is marked, and all distances set off from it. The information with regard to the rivet or bolt holes required may be obtained from a plan or from a beam list, which is simply a written specification giving all the necessary particulars for each beam, such as the spacing of the rivets in a way of plating and of bolt holes for wood deck fastenings, where there is no plating. The size of beam knee, and the number and size of rivets in same are also shown. When a beam has been completely marked it is cut to its proper length, punched and taken to the beam-bending machine.



75

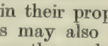
Bending of Beams. This is of a very simple nature, as indicated in **76**. B and C are two projections about 12 in. high, on a strong cast-iron table, and A is a movable ram. The bar to be bent or straightened, as the case may be, is laid on rollers on the table, and passed between A and B and C, while the ram A is made to move forward whenever required, and to any degree, thus pressing the bar against B and C, and bending it between these two points. The fact that B and C are adjustable points enables any curvature that can be applied cold to be given to a bar. A beam is usually first straightened horizontally. The deck flange is sighted by a man at the end of the beam, and whenever there is a hump towards A, pressure is applied until it has disappeared. The bar is then reversed, and the humps on the other side removed in the same manner. When the beam is straight in this direction it is laid on its side on the rollers and bent until its curvature corresponds with that of the beam mould, which is frequently applied during the process.



76. BEAM-BENDING MACHINE

Preparation of Beam Knees. The preparation of beam knees may go on concurrently with the bending of the beams. There are three kinds of these attachments to the frames—namely, bent, welded, and bracketed knees. Of these, the last are now the most common. They consist simply of bracket plates, as indicated in **77**, attached by rivets both to the beam and the frame. The plates for this purpose may be ordered from the steel works to the neat sizes, and the holes both for the frames and beam rivets may be marked from one template and punched. The rivet holes in the beam end may also be marked from the same template, but it is not wise to punch those in the frame, or at least all of them, at this stage of the work. These holes are usually left to be drilled when the beams and frames are erected and in their proper place. The plates for welded knees may also be ordered to neat sizes. In this instance, the work of making the knee is undertaken by the smiths. The piece of plate is simply welded on to the web of the beam, as indicated by **78**. When the knee is completed, the holes for the frame rivet are marked from a template and punched. The making of bent knees is very similar to the operation of making a welded one. The web of the beam is split by sawing for some distance from the end, and the lower part is bent. A small triangular piece of plate is then welded in the

77

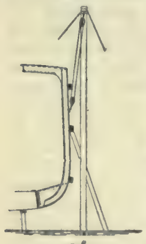


78

V-formed space between the two. The knee thus produced is, as a rule, rather more satisfactory than the previously described one, as the strength of it does not depend solely, or even mainly, on the efficiency of a weld, which rarely is equal to that of the solid plate.

79

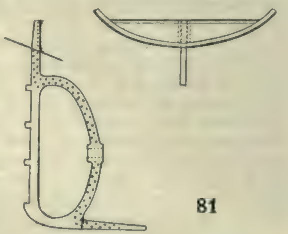
Erection of Frames and Beams. When the side frames and the deck beams have been prepared, or when some of them at least are ready, their erection may be begun. The frames are first placed in position by means of a simple derrick arrangement, formed by a tall pine spar suitably supported by stays, and bearing blocks and tackle, whereby the combined frame girder can be readily hoisted into position, as shown in **80**. When the frame is at the required height, the floor bracket is bolted to the vertical angles already fitted on the margin plate. The first few frames erected require to be supported at their upper end by shores and stays. When a number of them are in position, a couple of ribbands may be attached to them, as shown in **80**. This gives at once a little more rigidity to the system, and still more support is obtained when some of the frames on the opposite side have been placed in position, and a few beams have been fitted. The deck beams keep the long and somewhat flexible frames at their proper distance apart at the top, and the ribbands keep them at their intended spacing in a fore-and-aft direction. The ribbands are prepared by the carpenters, according to the information received from the drawing office or moulding loft. Near amidships they are straight, square-sectioned pieces of timber, with the position of each frame indicated on them. Amidships, the distance between the frame marks will be equal to the fore-and-aft frame spacing, but nearer the ends of the vessel the distance between the marks will be in excess of the fore-and-aft spacing of the frames, owing to the ribband being bent to follow the form of the vessel. The position the ribbands should occupy is marked on the frames when they are on the scrieve board.



80

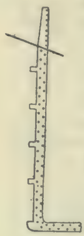
Plumbing of Frames. As the keel of a vessel is sloped towards the after end, it follows that the frames will not be vertical, but will also be slightly inclined towards the after end. In erecting the frames, great care must therefore be taken to see that the plane of a pair of them is at right angles to the keel bar or plate. The vertical inclination is determined by means of a plumb-line fixed to the centre of the beam. The point at which this line should meet the keel line abaft the position of the frame is easily determined from the known declivity of the keel. By means of the plumb-line it is also ensured that the centre of the beam is transversely exactly over the centre of the keel. The plane of the frames may now be fixed at right angles to the keel line, either by lines of equal length being brought from points at equal heights on the frames to a point on the keel line before or abaft the frame, or this may be achieved by stretching a line across the vessel from frame to frame, and ensuring, by means of a large square, that it is at right angles to the keel line. As the frames are being erected more ribbands are bolted to them, and more shores are fitted to give proper support to the structure. Shores and ribbands are likewise fitted to the deck beams to keep them in their intended positions. At this stage of the work it is very important that the frames are efficiently prevented by stays from tripping aft, as they would tend to do, owing to their inclined position, until some plates are fitted.

Stem and Sternpost. Before the extreme end frames can be erected, it is necessary that the stern frame and stem should be in position. These parts might be erected as soon as the keel is laid, but they are not usually ready till later. The sternpost is, as a rule, whether it be cast or forged, delivered in the finished state in the yard. At the most, it may be necessary to drill a few rivet holes in it. In ordinary single-screw steamers the stern frame is in one piece, as shown in **81**, and it is the heaviest single piece of material in the ship. It must be of considerable thickness to afford proper support to the propeller and the rudder. Where there is no propeller—as in sailing vessels, and in paddle and twin-screw steamers—the sternpost is simpler, as indicated by **82**, and much lighter.



81

The holes for the rivets attaching a sternpost to the shell plating are nearly all drilled by the makers. In way of the thick bossing for the screw shaft, and where the heel of the post joins the keel bar or plate, the holes may be drilled in the shipyard, when the sternpost has been erected in position on the aftermost keel blocks, and securely shored at the sides. The aftermost frames of the vessel are stepped on the arch of the stern frame above the propeller space, or screw aperture. The frame [**81**], which is attached by means of a deep floor plate to the rudder-post, or, rather, its continuation, is called the *transom*, and is usually numbered O, No. 1 being the frame just in front.



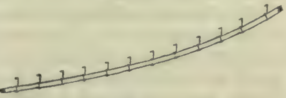
82

The stem [**83**] is a simple bar of rectangular section, and may be either forged, cast, or rolled. It is delivered straight in the yard if not cast, and bent to the shape on the slabs at the frame setting furnace, its exact curve being supplied through a mould prepared by the loftsmen or carpenters. All the rivet holes may be drilled by machine in the yard, or only those in way of the bend, the others having been done by the makers. The foremost frames are stepped on the stem, and their position is, therefore, carefully transferred from the mould to the stem itself. The landing edges of the shell plating are now also marked on the sternposts and stem, as on the frames; in fact, these bars may be considered as the first and last frame respectively.

83

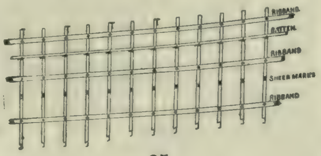
Fairing of Frames. The process of fairing has been described [see page 5613], when it was applied to the lines of a vessel with a view to getting a fair representation of the ship on paper. When the frames and beams of a vessel have been erected it becomes necessary to fair the entire surface of the actual vessel as represented by the frame and beam

lines, as it is otherwise impossible, in spite of the greatest care, to ensure the form of the vessel being fair. This work is undertaken by the carpenters of the yard, and is done by means of the ribbands, some of which are shown in **80**. Amidships, where the frames are all of the same form, the fairing process is simple, and consists only in sighting the heels of the frames to see that they are exactly in line. The cause of an odd one being out of line with the remainder might be a slight unevenness on the ribband where the frame is bearing against it. At the ends of the vessel more ribbands may be necessary to hold the frames in their correct positions. These timbers are curved, as shown in **84**, and tapered in thickness where the curvature increases, as they would otherwise be too stiff to allow of them following the surface of the ship. It is here necessary to sight the ribbands carefully to ensure that they are bent in fair curves, and the frames are then bolted tightly to them, so that the heel of the bar bears hard against the inner surface of the ribband. Shores are further provided to the ribbands at many of the frames to assist in the proper form being obtained as well as to support the structure. The deck beams are faired by ribbands on the top of them, just as the frames were faired. The work is, in this instance, rather easier, as the curvature is less.



84

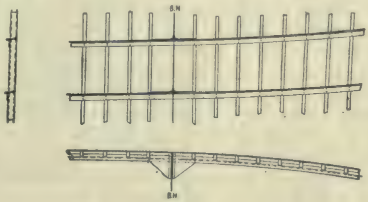
Fairing of Landing Edges. When the frames and beams are fair, the edges of the plating may be correctly marked on them. This is necessary in order that the men fitting the plating may have something to guide them as to where exactly each strake is to end and the next one to begin. The plates are ordered with only a minimum width of material to spare, and the widths of the plates supplied must be arranged so that they cover the entire frame, or beam, as the case may be, with the proper allowances for overlaps for edge attachments. It is also desirable, from the point of view of appearance, that the outside edges, particularly of the shell plating, should be fair lines, as they form very prominent features in the exterior of the vessel. The intended position of edges of the outside plating are, as already explained, marked on the frames at the time they were on the scrieve board, but the points thus obtained serve, in the first instance, only to indicate the places where rivet holes are not to be punched in the shell flange of the frames. In the second instance they serve as approximation points for the real edges of the plates which must undergo a fairing process before they can be adopted as correct. This process is in yard language termed the *sheering of the landings*. A couple of loftsmen or carpenters do this work by means of long battens, which are fairly broad so that they may not deflect unduly laterally, and also thin in order that they may at the same time follow the curvature of the vessel, with the application of a minimum of force.



85

They are held in position on the frames by means of clips as indicated in **85**. In addition to the marks nicked on the frames the workman is furnished with a list of the breadths of all the plates as ordered from the steelmakers, because he has to arrange that not only all lines of the edges of plates are fair, but also that the lines thus determined are compatible with the actual size of each of the plates ordered. The sheering of the landings usually begins at the keel or garboard strake, where they are straight and parallel to the keel line for the greater part of the vessel's length, and the other landings are successively dealt with. There are, of course, two edges to each landing, but the one worked to in the fairing process is the one that would be seen from the outside when the vessel is plated. This line determined, the other one is easily fixed in relation to the first by the list of widths of overlaps that is also supplied to the workman. When one landing has thus been marked on one side of the vessel the exact marks are transferred to the other side, where no fairing is then required.

The Fitting of Stringers in Hold. The stringers which are usually fitted in the holds of ships are now very small and of a simple character, as shown in **86**. They consist chiefly of a single angle on the face of the reversed frames, which is attached to the shell plating by means of intercostal plates and angles. The positions of the stringers are marked on the reversed frames while on the scrieve board, and no more fairing is necessary here then can be done by the workmen fitting the stringers. The uppermost of these usually run nearly parallel to the deck, while the lower ones are approximately horizontal amidships and turn upwards at the ends of the vessel. The main stringer angle is fitted first by using long templates of the width of the broad flange of the angle. These battens are temporarily fixed in the correct position of the angle and the rivet holes in the reversed frames, and lugs, if such be fitted, are transferred to the template.



86

The rivet holes in the other flange of the angle may be marked on the other side of the template, which can then also be used for the corresponding holes in the intercostal plate. There is no bevel given to the angles of hold stringers, as these girders are fitted square to the side of the vessel. The bars and plates have very little curvature for the greater part of the length of the vessel, and may be bent in place by means of iron bolts drawing them up to the frames. At the ends the curvature may be greater, and it may be necessary to bend the plates and angles somewhat in the beam-bending machine or on the frame-setting slabs to a rough mould or merely to the eye judgment of the workman. The intercostal plates are usually fitted in long lengths and scored out for the frames as shown in **86**. The fitting and riveting up of hold stringers add considerably to the rigidity of the structure generally before the shell plating is in position.

Continued

THE PRINTING OF BOOKS

The Early Hand Press and its Modern Equivalent. Single and Double Cylinder Machines. The Wharfedale, Miehle, and Perfecter Machines

By W. S. MURPHY

THE invention of letterpress printing was a great achievement, but the early printing press was a poor piece of mechanism. In conception highly ingenious and admirably adapted to its purpose, the press was badly constructed.

The Early Printing Press. It was a kind of screw press. Two stout beams supported the cross-beam, which held the screw firmly bolted into the platen or pressing-board. A handle was fixed through an eye in the lower end of the screw. Resting on a strong frame, the type-carriage, or coffin, contained a smooth, flat stone to give an even surface to the bottom of the type, and loosely hinged on the outer end of the carriage sat the *tympan* and *frisket*. These last were frames, the former filled in with two ply of parchment, the latter covered with paper. The tympan was a double frame, front and back, the back frame being detachable. On these parchment was stretched, like the head of a drum, and between them lay several folds of paper and woollen cloth, in modern practice blanket. Similarly, stout paper was stretched on the frisket. The page to be printed was laid, the face of the type upward, on the bed of the carriage, and firmly locked in. At the side of the pressman stood another workman, who manipulated a pad on a stone slab, on which a sticky ink was spread, and who dabbed ink all over the surface of the type. The pressman laid a sheet of paper on the inked type, folded down the frisket on the tympan, folded the tympan on the type-carriage, and together the two men pushed the carriage along to where the page would lie just under the centre of the platen.

Hand Printing. Then they took hold of the handle of the screw and pulled it round, depressing with considerable force the platen on the type-carriage and its contents. The carriage was drawn out again, tympan lifted, frisket flapped up, and the sheet taken off—printed. The page left a deep impression on the tympan. The pressman ran his knife round the edge of the impression on the frisket, and cut it out, leaving a hole a little larger than the page. He used the mark on the tympan sheet differently. Carefully measuring, he fixed on the sheet at proper distances tabs, or slips, or pins, which held a sheet so that it fell evenly, and in correct position on the page. But he had not finished. Observing that the impression was not regular, one part being deeply impressed and another faintly, he pasted thick pieces of paper on the faint parts, paper not so thick on the parts less faint, working it all up to a level of impression. Then he was ready to take another proof. The frisket was folded on the tympan, showing that it was designed to protect the sheet from the furniture surrounding the type; the tympan was folded on the type-carriage, and the printing repeated.

The Modern Hand Press. From the above it will appear that, crude though the early printing press was, it embodied every principle of the most modern hand press. Frisket and tympan in the latter are iron framed and hinged; the bed of the carriage is wrought iron, hard as steel, and the type-carriage itself is iron, running on smooth, steel rails, driven by a belt; the platen is broad and smooth and heavy; the screw has given place to levers and springs ingeniously devised to lighten labour; but in no particular has the principle changed. The modern hand press saves time and labour, and enables the workman to produce better work.

About the middle of the seventeenth century, some very important improvements were made by Jansen Blaeu, of Amsterdam, who devised a winding belt by which the type-carriage was drawn under the platen, and attached to the screw a spring, which, while assisting the pull, drew the screw back to its place. Another century and a half passed without much improvement on the Dutchman's invention, and then, on the threshold of the nineteenth century, Earl Stanhope brought out his iron press, which, besides being the first to print a sheet at one impression, introduced the lever principle.

The Columbian Press. In 1812 our American cousins sent over an improvement on the Stanhope press, still in use, and aptly named the Columbian press. This press is loose and heavy in construction, but it is easily worked and suited to large formes, posters, and heavy work generally. The chief feature of the Columbian press is the huge iron slab across the body of the frame, balanced on the shaft of the platen, and counterpoised by a heavy weight fixed on a rod at the back, and an eagle sitting on a long bar on the head of the frame. At rest, this iron beam slants upward, and at the upper end double elbow joints connect it with the horizontal bar fixed in the socket of the handle. When the handle is pulled, the beam is brought into a horizontal position, resting its weight on the platen shaft, and pressing down on the platen. Released, the handle flies back, and the beam resumes its slanting pose.

The Albion Press. The Albion press [38], invented by Cope, is typical of British engineering. Compact, well wrought, and finely finished, this press also works on the lever principle, but with less weight than the Columbian. From the head of the handle an iron bar connects with an irregularly-shaped crank of great weight, with a finger on its underside that fits into the socket of a tumbler, or wedge, set in the head of the

short shaft of the platen. The tumbler slants when at rest, but when the handle pulls the crank, the finger brings the tumbler into a vertical position, and presses down the platen. No bolts secure the ingenious mechanism; but, actuated by a spring in the head of the press, a long bolt comes down, and holds the crank and tumbler firmly yet freely together by mere pressure.

In newspaper offices the hand press has little to do, except giving off proofs of process blocks and odd pieces. In book establishments the position of the hand press is curious. On the one hand, it is used only for proof work; but, on the other hand, in the plate and engraving department, as we shall see, the oldest form of press is the honoured tool of the artist.

Rollers. Rollers are the tools with which the printer distributes the ink over the type, and are therefore indispensable. The body of the roller is a composition, generally treacle and glue, moulded on a core. Hand rollers are cast on a hollow core, brass tipped at each end, to hold the iron rod that links into the ends of the bent bar in which the handle is set. Rollers may be of any size needed for the work, 2 in. or 6 in. in diameter, 6 in. or 6 ft. long. Machine rollers are cast solid on an iron core, the ends of which are spindles, for taking on driving gear, and sitting in the forks on the side frames of the machine. The soft, elastic, smooth, and slightly adhesive material of which they are composed makes the rollers draw out the thick ink to thinness, and softly treat the type.

Ink and Ink-tables. Printing ink is practically thick paint, with the addition of a stiffening varnish. The object of inking is to cover the type with the thinnest of thin coats of pigment; it should therefore be worked to complete smoothness before the roller is allowed to touch the type.

The best and most durable ink-table for the hand press is zinc-covered on the top [39]. The ink is spread at the back of the table, and from this stock the workman takes additional supplies, as required, mixing it well to smoothness before again using the roller. The tables of the various machines are described in connection with the machines themselves.

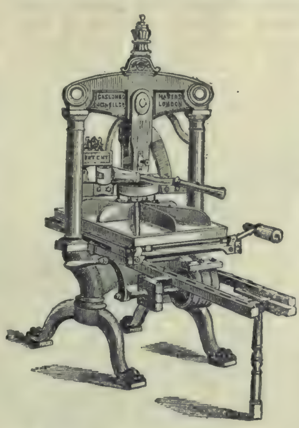
39. INKING-TABLE AND ROLLER FOR HAND PRESS

Simple as these facts appear, some experience is needed for the proper use and care of rollers. Cleanliness here, as in most things, is a prime virtue.

Cylinder Machines. After many experiments, "The Times" was printed in 1814 on a cylinder machine, steam-driven, invented by a German named Koenig, and before the middle of the century several good machines had been produced; at its close the printing trade possessed a wealth of mechanical appliance greater than the wildest hope could have imagined. Printing machinery is the finest product of the engineer; for accuracy of adjustment, rapidity of movement, directness of action, and harmony of parts, the machines are unrivalled in the world of mechanics.

The Four Classes of Machines. Printing machines belong to four classes—the platen, the single cylinder, the double cylinder, and the rotary.

Platen machines belong to the jobbing department, and fall to be treated under that head; *rotary* machines occupy a class by themselves; they are the machines of the newspaper, periodical, magazine, or popular book factory, and require a separate chapter. We will here deal with the *single* and *double cylinder* machines.



38. THE ALBION HAND PRESS

The Wharfedale. To select one machine from a class so numerous seems invidious; but no book of reasonable dimensions could contain detailed description of even half the machines on the market. We, on that account, restrict ourselves to a single representative of its type, the Wharfedale.

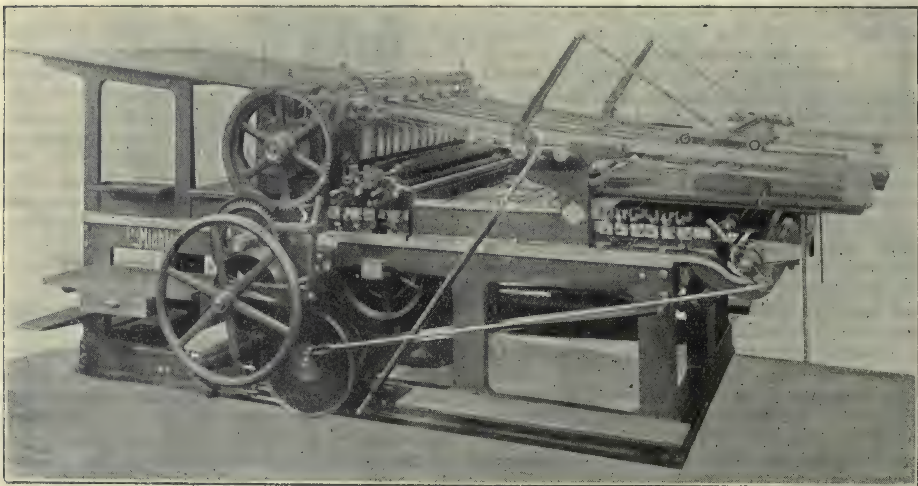
This machine mainly consists of a cylinder mounted upon parallel side frames, firmly bolted together by cross-bars, and a flat type-carriage, or coffin, with inking-table attached; the sheet feeding board at one end, and the taking off board at the other, cover in the mechanism, all but the cylinder, like two lids. The cylinder is a large hollow roller, having an aperture 5 in. broad along its whole length. Held on the top of the side frames by gun-metal brackets and bearings, the cylinder has no motion of its own. Within the body of the cylinder, at each side, a ring of teeth is deeply cut, and these correspond to the rows of teeth on both sides of the coffin. We shall see them act together presently.

Mechanism of the Single-cylinder Machine. The centre of the motion of the machine is the coffin, or type-carriage. From the main driving-shaft a strong steel connecting-rod propels the set of toothed wheels that impart to the type-carriage its reciprocating motion. Travelling forward under the cylinder and back again with unfailing regularity, the type-carriage is a flat slab of steel, resting on rails, with small rollers beneath its centre to facilitate its motions. Behind, and of a piece with it, is the inking-table, with ink-duct containing the ink supply and two mixing rollers lying across it and set in forks fixed in the side frames. The ink supply is regulated by a ratchet gearing at the side,

and as it oozes out the mixing rollers distribute it smoothly over the table. Further along, in a position where they come in contact with both type-carriage and ink-table as they move to and fro, lie three other rollers, which transfer the ink from the table to the type. Before starting the machine, the feeding and flying apparatus must be observed. Along a bar fixed in the opening of the cylinder a series of brass fingers, called grippers, are fixed. A spring inside the cylinder holds the grippers tight, and by a short arm acting on a solid pulley at the side, they are opened. On the other side of the cylinder a curious combination of lattice tapes and forks sits across the machine. This consists of two wooden rollers, set about a yard apart, and between them the tapes are stretched. The one roller sits above the cylinder, and is equipped with grippers so geared that they come into the opening of the cylinder at the proper moment and take away the printed sheet. The tapes bear it off and give it to the flyer—a set of wooden lathes fitted on to a stout bar that derives its flying motion by means of a cam from the main shaft.

Starting the Machine. The driving-belt is put in position, the main shaft begins to turn, the carriage bearing the forme moves to and fro, the inking-table with it, and the feeder takes his sheet from the board. With one hand he touches a lever that brings the cylinder into gear, and with the other sends the sheet against the grippers. The type-carriage has come forward and the toothed racks on each side pull the cylinder round with the sheet in its hold. Type and cylinder close, and the sheet is printed. As the sheet comes up again it is gripped by the taking-off apparatus, borne along the tapes to the flyers, which flop it face downwards on the board. And all the time the rollers have been mixing the ink and inking the type as table and type-carriage moved to and fro.

The "Miehle" Two-revolution Press. Among the latest improvements in printing machinery is the introduction of the "two-revolution" action, of which the "Miehle" [**40**] is considered to be the best embodiment. Like the Wharfedale, it prints on one side only, but operates more swiftly and accurately. Similarly, though the feed-sheet and flying arrangements are improved, they do not differ in principle from those already described. A printer who has learned to work the older machines would have no difficulty with the "Miehle"; in fact, he would find his work easier, after he had got into the way of the newer machine. One feature of the "Miehle" is worthy of special notice. Though only a single-cylinder machine, it has been successfully used to print two-colour and three-colour illustrations. Two, or in the latter case three, machines are placed in tandem, and connected with the same drive. The sheet passes through the machines in continuous succession, and they are so exactly alike in every particular that an illustration as perfect as though printed on a single machine is produced.



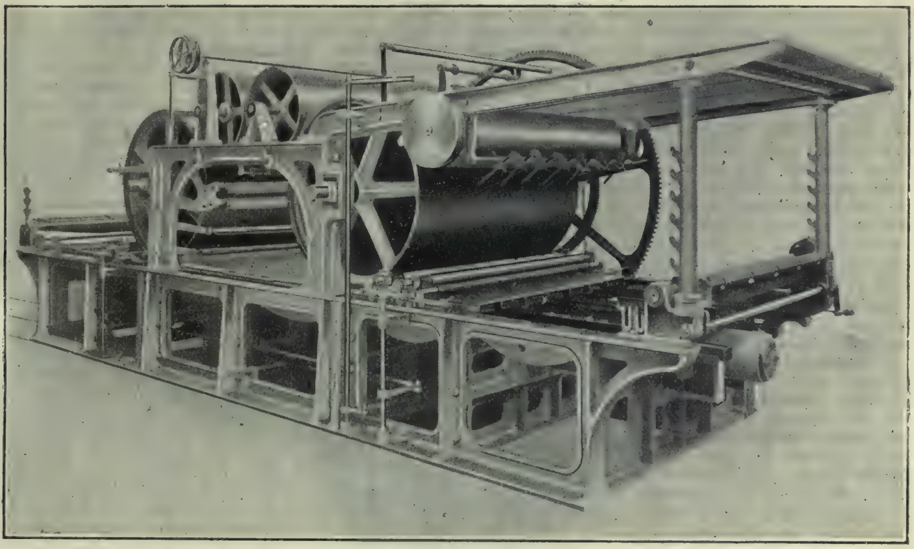
40. THE MIEHLE TWO-REVOLUTION SINGLE-CYLINDER MACHINE (Linotype and Machinery, Ltd.)

Double-cylinder Machines. In the year 1818, a firm of machinists, Messrs. Applegarth & Cowper, produced a double cylinder machine, designed for printing books. Our interest in this machine is more than historical; it is practical; for in many of the best book-printing establishments slightly improved "Applegarths" are still used. The huge framework, 15 ft. long by 5 ft. broad, holds within it two large hollow cylinders, 9 ft. in circumference, 2 ft. apart, and revolving towards each other. Between the cylinders hang two wooden drums, running in opposite directions. Very conspicuous are the endless tapes winding round the two cylinders, two sets coming from opposite directions, and crossing each other stretched on tape-bars, going together round the first cylinder,

parting in the middle, the one to go over the centre drum, the other passing round a tape-bar low down, and meeting again on the second cylinder. No sheet could be expected to run true on cylinders so wide, and those tapes are designed to hold the sheet straight, and they part in the middle to let the sheet free after it has been printed. The two middle drums have also an important function to perform. When the sheet has been printed on the first cylinder, it must be reversed to print on the second. The two drums turn the sheet and deliver it to the second cylinder with the printed side uppermost. To drive those huge cylinders on the tooth and pinion principle of the Wharfedale would involve an enormous strain on the type-carriage; therefore, they are driven direct from the main shaft in the ordinary way. Otherwise this machine is similar to the Wharfedale, and, working under ordinary conditions, runs at the rate of 700 copies an hour.

it appeared to the inventors, Messrs. Donkin & Bacon, that greater speed could be obtained by another method. This was done by mounting the carriage on an ingenious combination of rack and pinion wheel. This pinion wheel, fixed on an upright shaft, reels the type-carriage forward under the cylinder, and then by an arrangement of moving bars, the rack is pulled round to the other side of the pinion wheel, which sends it and the carriage in the opposite direction.

The sheet is fed into the grippers of the first cylinder, and is held by the tapes while the cylinder revolves on the incoming type-carriage. Guided by the bands, the sheet printed on one side travels through the reversing drums, which turn it over, and present it properly to the second cylinder. After passing through, the sheet drops down, printed on both sides. If the type has been correctly laid, every two consecutive pages, odd number and even, will lie exactly



41. THE MIDDLETON PERFECTING DOUBLE-CYLINDER MACHINE (T. Middleton & Co.)

The Perfecter Machine. There are between 20 and 30 different machines of the perfecter type at present in use. Some are only combinations of the Applegarth and Wharfedale machines, with minor variations; many, indeed, are double Wharfedales, labelled with fancy names, and nothing more. To avoid needless repetition, and add to the knowledge of the reader, we select the machine generally known in the trade as the *perfecter* [**41**], and possessing special features. In its "upper works" this machine resembles the machine described above, excepting that it is lower set and easier to get at. The prime characteristic of this machine is the arrangement by which a swift reciprocating motion is imparted to the two type-carriages. With the impetus of such a heavy body to control, the Wharfedale arrangement might have seemed the safer; but

on the back of each other, or, in technical phrase, the pages are in *perfect register*.

The Marinoni. The Marinoni machine differs in several important details from the ordinary perfecter. The cylinders are set close together, intermediate drums being dispensed with, and work in gear on two pairs of upright movable frames which alternately lift them up and down. By a rocking motion, automatically regulated, the cylinders dip down on the incoming formes, and lift to let them pass back. Unlike most other double cylinder machines, the Marinoni has not two separate type-carriages; the two are simply divided by a bar. This entails some modifications of the ordinary perfecter mechanism. The Marinoni is a very complex structure, but when kept in working order it produces fine printing at high speed.

Continued

Group 24
PRIME MOVERS
3
Continued from page 5645

TYPES OF STEAM ENGINES

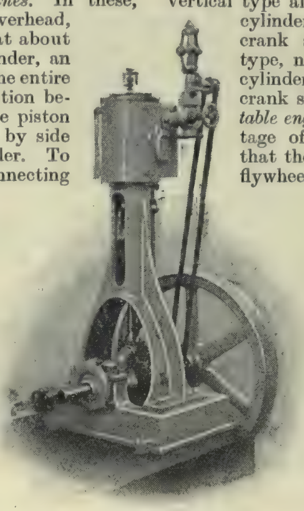
Principles, and Construction of Beam, Vertical, Simple, Compound, and High-speed Self-lubricating Engines

By JOSEPH G. HORNER

THOUGH engines vary to an almost infinite extent in their details, the very broad types admit of classification.

Beam Engines. These are the oldest forms, the direct descendants of the first mine pumping engines. They are still made, but in small numbers, though with all modern improvements embodied, and still chiefly for pumping stations. There is no objection to the engine as such. It is a useful and durable type, and can be built to yield as high efficiency as any modern engine. But the fact that engines of other types of equal power occupy less space has led to a lessening demand for it. Curiously, it is retained on American river paddle steamers, and was for long used on ocean service in a modified form—that of the *side lever engines.* In these, instead of a single beam situated overhead, two beams were located low down at about the level of the base of the cylinder, an arrangement made in order to get the entire engine beneath the deck. Connection between one end of the beam and the piston rod and its crosshead was effected by side rods, one on each side of the cylinder. To the other end of the beams the connecting rod was attached by the medium of a crossbar; and the crank connected end of the rod—in this case, the upper end—rotated the paddle-wheel shaft.

A common beam engine of modern type possesses the following elements. The cylinder, with its axis set vertically, and driving to one end of the beam, pivoted thereto with a *parallel motion.* The beam is of cast or wrought iron, with large trunnions rocking in bearings carried on an entablature on pillars. The connecting rod, pivoted to the other end of the beam, turns the crank and flywheel. The cylinder is *jacketed* with steam, and *lagged,* or cleaded, with wood or sheet metal, enclosing felt or some other non-conducting material. The beam is utilised as a means of attachment for various dependent pump rods. The *air pump* for pumping hot water and air out of the condenser into the hot well is actuated by its own rod. The pump is in direct communication with the condenser, which receives the exhaust steam from the cylinder. The condenser is set in a large tank of cold water, to supply which is the function of the *cold-water pump,* also operated from the beam. The *feed pump* takes water from the *hot well,* and delivers it to the boiler.



19. VERTICAL ENGINE

Vertical Engines other than Beam Engines. For nearly a century there was prejudice against the use of any engines in which the axis of the cylinder was not vertical. It was believed that the cylinders and pistons of horizontal engines suffered more wear at the bottom than at the top, and that friction was more severe in these. This partly explains the long persistence of the vertical type. But there are other reasons why the latter is used very extensively at the present period. First, it is compact, and occupies less ground area than a horizontal engine of equal power. Secondly, it is more convenient for some classes of driving, notably central station work. In others, it is practically the only design possible, as in the modern marine screw engines. Hence, vertical engines occur in a range of dimensions which include alike the smallest and the largest sizes of engines manufactured, or from 2-horse power to several thousands of horse power, and in non-condensing and condensing types.

General Arrangements. An engine of vertical type almost invariably has its cylinder or cylinders in the highest positions, and its crank shaft in the lowest. There is a type, now nearly obsolete, in which the cylinder was carried on a table, and the crank shaft was overhead, hence termed a *table engine.* It was unsteady. The advantage of having the cylinders uppermost is that the weight of the rotating crank and flywheel is kept low down, and the centre of gravity of the engine is lowered, and the tendency to vibration lessened. Moreover, the engines are generally designed so as to mass much dead weight about the base. The uprights, or standards, are spread out widely, giving a large area of base, and box sections are adopted for the standards, so that the engines run steadily. The up and down reactions, due to the movements of the piston, are minimised by bolting the framing down to secure foundations.

The framings of vertical engines may be cast solidly, or built up in two or more parts. A common and neat design, suitable for the smaller types, is that in which the entire standard is a solid casting [19], made partly or wholly by coring out, including in it the crosshead guides, and in many cases the crank shaft bearings and foot. In some designs the cylinder is also cast in one with it, and a jacket cast around the cylinder; but the risks of a large waster casting in the foundry are then increased.

Another common design for both little and big engines is that of two standards bolted on a base plate, the cylinder being bolted to the tops of the two standards. Below the guides the legs spread out for stability, and to clear the sweep of the crank. The crank shaft bearings are cast or bolted to the base plate, and the central portion is recessed to clear the crank and connecting rod end.

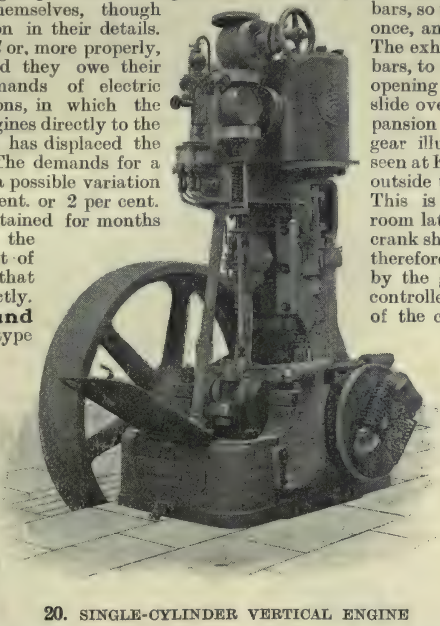
In another design, a single standard is used bolted on, or cast in one with a base [20]. The cylinder is

bolted above, or sometimes to a vertical face of the standard, and the crank shaft bearings are on the standard, or more commonly on the base. The cylinder fitted thus overhangs, which may be the cause of unsteady movements. Hence, in most engines of this kind, additional support is given in the form of a strut between an extension of the top of the standard and the base, seen in the front of the illustration.

There are no engines larger than those which propel the great ocean liners with the combined power of from 20,000 to 30,000-horse power or more. These are all now of the top, or *inverted cylinder* type, with standards built on the double model attached to a base or bedplate. These are all of compound types, often including six cylinders with their fittings, to a single set of engines, to which another notice will be given in a later section.

There is another great group of vertical engines, which form a class by themselves, though subject to much variation in their details. They are termed *high speed* or, more properly, *high rotative* engines, and they owe their development to the demands of electric lighting and power stations, in which the practice of coupling the engines directly to the dynamo which they drive has displaced the older belt connection. The demands for a high rotative speed, with a possible variation of not more than 1 per cent. or 2 per cent. from normal speed, maintained for months continuously, has been the cause for the development of some marvellous engines that fulfil these conditions perfectly.

Vertical Compound Engines. A favourite type of engine is that shown by the illustration [21], one made by Ransomes, Sims, & Jefferies, Ltd., a single engine built on precisely the same model as **20**. Engines of this general build—inverted cylinder type—are largely used for ship lighting purposes. The main framings, as already briefly noted, are often modified. The following are the leading features to be noticed in this design.



20. SINGLE-CYLINDER VERTICAL ENGINE

The engine bed plate A, which is in one hollow casting, carries the whole of the engine quite independently of the bed below it, which receives the dynamo, and on which the self-contained engine is bolted. The half section to the left at *a* [21] shows the *crank pit* in section, in which the cranks and their counterbalance weights dip. The style of standard B, similar to that in 20, has the advantage of leaving the whole of the front of the engine open to inspection. What it lacks in front support is provided by the diagonal steel pillars CC [21], set in the plane of the axis of the cylinders. The guides are necessarily flat faces only, and the strips *bb* confine the crossheads D. The connecting rod top end brasses have provision for taking up wear by means of the wedge-shaped cottar bolt *c*. E and F are respectively the high and low-pressure cylinders, and their valves are shown in section at G and H. J is the throttle valve through which the steam supply passes to the high-pressure cylinder E.

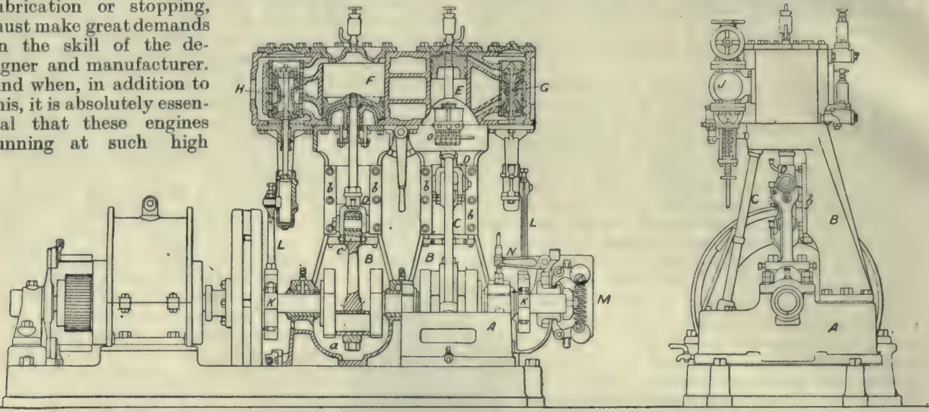
We now meet for the first time with piston-valves, G and H. The reason why these are used in preference to the D slide-valves of **5** [page 5658] is that they work in equilibrium, and so avoid the severe friction of the slide-valves when steam of high pressure is used. The steam presses equally around the piston-valve, and the only friction is that due to the close contact of the valve in its liner. The valves and seats in good practice are turned, bored, and ground. Metallic spring rings are used in order to maintain the valves steamtight as they wear. But in consequence of the large circumferences in contact, the wear of such valves is very minute in amount, and they often run for several years without requiring renewal of the rings.

Looking at the valves G and H, the annular portions at each end, which contain the rings, open and close the ports. The ports are of annular form, surrounding the valve faces, except for the division bars, so that steam enters all round at once, and thence enters the passages. The exhaust port is also annular, with bars, to prevent the spring rings from opening out into the ports as they slide over them. The amount of expansion is fixed in the type of valve gear illustrated. The eccentrics are seen at K, and the eccentric rods LL lie outside the axis of the valve spindles. This is necessary in order to give room laterally for the cranks and the crank shaft bearings. The valve-rods, therefore, are maintained truly in line by the guide. The throttle-valve is controlled by the shaft governor M, of the centrifugal type, acting upon the throttle-valve J by means of the lever N. The speed can be regulated by a hand wheel. Provision for lubrication will be noted. O is one of the two central oil-boxes whence brass pipes, not shown, pass to the moving parts below. Various oil-cups in connection with these pipes will be seen in the views. The great depth of the pistons conduces to durability.

High-speed Self-lubricating Engines. These engines [22 and 23] are the outcome of the demands of electric lighting. The earlier practice was to drive the dynamos with belting from separate engines. This occupied much floor area, and was not sufficiently steady. The present practice is to couple the dynamo directly to the crank shaft of its engine, which is a compact arrangement. But this requires that the engines shall run at the same speed as that at which the dynamo must run, since there can be no speeding up as by belting; hence the term *high-speed* engines. The high speeds of torpedo boats have also been a potent cause in the growth of these engines.

The term "high speed" does not, however, imply an unusually high *piston speed*, for many mill engines of long stroke have a higher speed of piston stroke. The term relates to the rotational speed, for, while the stroke is short, the speed of rotation ranges from about 250 to 650 revolutions per minute, according to the power of the engine; hence the term *high revolution* is more appropriate.

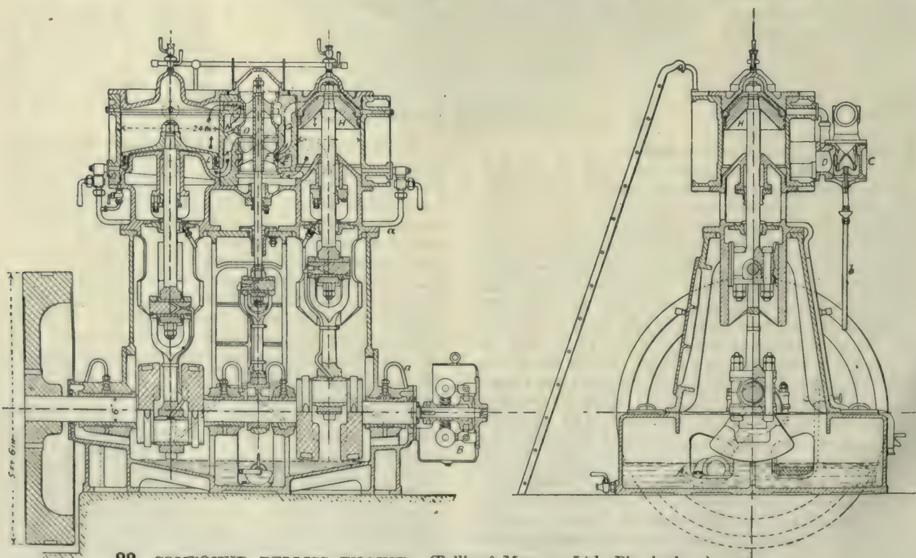
Now, four to ten revolutions per second of heavy cranks, and twice that number of reciprocations of heavy pistons, crossheads, and connecting-rods, to be accomplished noiselessly, and to run thus, say, for a twelvemonth absolutely without attention or lubrication or stopping, must make great demands on the skill of the designer and manufacturer. And when, in addition to this, it is absolutely essential that these engines running at such high



21. COMPOUND HIGH-SPEED VERTICAL ENGINE (Ransomes, Sims, & Jefferies, Ltd., Ipswich)

speeds shall not vary more than, say, 3 per cent. from the usual rate of running when working between the full load of a central station and no load at all, the conditions are extremely stringent. Yet these engines are guaranteed to accomplish all this, and do so, year in, year out, at numerous electric lighting and power stations.

The Belliss Engine. The best known of these pioneer types are the Belliss (shown), and the Willans, to be illustrated later. The compound engines [22] are completely enclosed (compare with 23), the only moving parts visible being the flywheel and the lower part of the piston, and valve rods. The base, or the *crank-pit*, is made to form a receptacle for the oil used in lubrication. This is indicated by the shading in the drawing. A valveless pump, A, takes the oil, and distributes it through an elaborate system of oil channels, several of which, *a a a*, can be traced on the drawings, distributing it to the various bearings at pressures which may range from 10 lb. to 20 lb. per square inch. The waste oil drains back into the tank, to be used over and over again. This device, now grown familiar, was originated by Messrs. Belliss & Morcom in 1890. It has been proved that a compound engine of 150-horse power does not require a supply of more than 4 gallons of oil in a period of 3,188 working hours, being at the rate of $\frac{1}{100}$th of a pint per hour. Nor is economy and automatic running the only advantage. The regular and full supply taking place under pressure, forces a film of oil between the bearings, and so prevents knocking, noise and wear. Over and over again engines that have been running for four or five years have been overhauled, only to find that the amount of wear has been so small that it could only be measured in such figures as from $\frac{8}{1000}$ in. in several cases



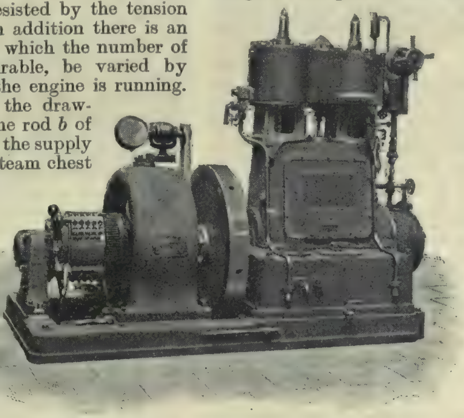
22. COMPOUND BELLISS ENGINE (Belliss & Morcom, Ltd., Birmingham)

to $\frac{6}{1000}$ or $\frac{1}{1000}$ in. The oil does not become contaminated with dust, because the parts are enclosed. Neither can any of it splash outside.

Governing. The governing of these engines, by which extreme variations in load applied produce only from 2 per cent. to 3 per cent. difference in the number of revolutions of the engine is a feature of much value. The governor, shown at B, is of the *shaft type*—that is, it is fixed on the crank shaft instead of being driven from the shaft by belt, chain, or gears. Shaft governors are practicable only when the rotational speeds of engines are high, otherwise governors must be driven by belt or gears to give them an increased rate of speed over that of the engine. The governor is also of the centrifugal type, as distinguished from those which are based on the cone. The centrifugal action of the balls is resisted by the tension springs attached to them. In addition there is an adjusting spring by means of which the number of revolutions can, when desirable, be varied by turning a hand wheel while the engine is running. This spring is not shown on the drawings, nor the connection to the rod *b* of the throttle-valve C, by which the supply of steam to the high-pressure steam chest is governed. This valve, C, is of the equilibrium, or double-faced type, which we shall meet with in other forms. It has the merit of opening and closing with a minimum expenditure of power and frictional resistance, due to the fact that the power required is only that corresponding with the difference of area opened by the two faces. The results given by these governors are excellent, and these engines are therefore highly suitable for electric tramways and railways as well as for electric lighting. Six sets of these engines supplied to the Waterloo and City Electric Railway in 1898 were required to be more sensitive even than is usually required. The load in the tube varies sometimes from the maximum to nothing within a few seconds. A specially sensitive governor was therefore fitted to these engines, and a flywheel heavier than usual. With a load that varied from 50 amperes to 330 amperes, the variation in speed, including the momentary variation, was only three and a half revolutions, or from 380½ revolutions to 384 revolutions. This was less than one-half of 1 per cent. from the speed corresponding with the average load.

Steam Passages. The arrangements of the steam passages can be traced out clearly in the drawings [22]. Steam passing through the throttle valve C enters the steam inlet passages D and E. The valve F, operated by an eccentric from the crank shaft, is open to lead, admitting steam from E into the passage G of the high pressure cylinder, so pushing the piston H downwards. The steam below H is now exhausting through the passage J, and goes through the slide valve into the passage K, past the edge of the valve O. O, being on the same stem as the valve F, partakes of its motion, and, moving upwards, admits full steam at the bottom of the low pressure piston L, pushing it upwards. Steam now exhausting from above the piston, enters the passage M and the exhaust passage N, and so out through the pipe, the flange of which is seen dotted behind it. Thus the steam enters alternately the top and bottom of the high and low pressure pistons, which is the reason why the passages are long and short respectively. The cylindrical valves F and O are designed for a fixed rate of expansion, but automatic variable expansion is provided for in some cases.

There are a number of interesting details about these engines which can only be mentioned. They include the counterbalance weights to the crank shaft which conduce to steadiness of running, holes in the periphery of the flywheel to bar it round with to start the engine, a solid disc to the flywheel to reduce air friction, drain cocks to each of the cylinders, the spring rings of the piston, the sheet steel lagging to the cylinders, the fitting of the glands, the design of the main bearings and of the crosshead. The engine illustrated is of 10 in. stroke, the high-pressure cylinder of 15½ in. bore, the low-pressure of 24 in. The steam pressure used is from 140 lb. to 150 lb. per square inch. In addition to the compound type as illustrated, self-lubricating engines are also made in other varieties, as single-crank simple, single-crank tandem compound, three-crank simple, three-crank compound, and three-crank triple expansion.



23. BELLIS COMPOUND ENGINE

Lubrication. The method of lubricating this class of engine is one that has much interest for engineers. The same principle is largely adopted in machine tools of automatic and semi-automatic types. Oil is forced by a pump, generally of centrifugal type, through piping to the localities where it is required. It is used over and over again, being filtered for the purpose. Cutting tools and work are thus kept cool, and the production increased. When, as in these engines, oil is forced between bearing surfaces, wear is impossible, simply because the surfaces never come into actual contact. It does not matter how thin the film of oil is; it may be only $\frac{1}{10000}$ part of an inch, but it suffices to separate metal from metal. Moreover, a light, thin, cheap oil can be used, which could not be employed if the oil were fed by gravity alone. A thin oil would run away too quickly, and hence a thick oil, with more body, and more expensive, would have to be used. Also, with automatic lubrication, one man can look after several sets of these engines. The oil is filtered through a strainer in the bottom of the crankpit, and is drawn off at intervals through the drain cock in the bedplate seen near the ladder. A little water becomes intermixed with it from the cylinders, for a feature of these engines is that any condensed water in the cylinders must drain downwards. The doors can be removed for the inspection of the engine without any oil splashing out, because the cranks do not dip under the oil at all. In engines where the cranks splash up the oil, this is sometimes inconvenient.

Continued

Group 5
APPLIED CHEMISTRY
11
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ELECTRO-CHEMISTRY, WATER-SOFTENING & WASTE PRODUCTS

By ALEX. A. BEADLE, CLAYTON BEADLE, and HENRY P. STEVENS

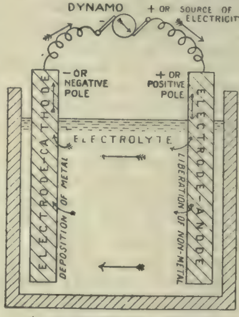
ELECTRO-CHEMISTRY

Broadly speaking, the term *electro-chemistry* covers every branch of knowledge and of applied science or art in which electricity and chemistry *together* constitute the most prominent features, but it is our purpose, in this course, to treat of those principles which have been actually made use of in the manufacturing world, and also to describe some of the processes themselves as they are actually in practice in the present day. Over 1,300 years ago Zosimus recorded the fact that iron immersed in a solution containing copper acquired a coating of the latter metal, and as late as 1690 a learned professor of chemistry in Helmstadt believed that iron could be changed into copper in this way. In about the year 1799, Volta gave the world his voltaic battery, which enabled Wollaston and Cruikshank to discover that by means of a voltaic current of electricity metallic copper could be deposited on to any metal.

Electricity in Chemistry. These men further showed that what was supposed at first to be a transmutation of iron into copper was in reality only part of the iron changing places with the copper in the liquid, so that, whereas some of the iron dissolved in the liquid, a *corresponding* amount of copper was deposited on to the surface of the iron, in metallic form, and what at first appeared to be a transmutation from iron into copper was really an *interchange* of metals by a self-contained *electro-chemical* process. In 1831, Faraday found how to produce electric currents by mechanical means, and he also did much vital work in connection with the laws of electro-chemistry. From this time onward the science developed rapidly; voltaic batteries were improved, electroplating was developed, electrotyping became an art, and at last the refining and extraction of metals was brought about successfully by the aid of the electric current. It is much to be regretted, however, that the mysterious agencies of electricity and electrolysis have been exploited only too often by clever quacksalvers, and have been credited with supernatural healing powers in every form of disease. The credulous public would do well to look more to the enlightened members of the medical profession than they have hitherto done, and it is to be hoped that, as electricity becomes more fully understood, they will be better able to distinguish between what is rational and useful and what is wicked and useless in this direction.

The General Principles of Electrolysis. To the general public electro-chemistry is an unexplored region, with names and terms entirely foreign. But to elucidate clearly the processes with which we are going to deal it is absolutely essential that a clear understanding of the most vital department of electro-chemistry—namely, *electrolysis*—be first obtained, and the student should first master the few technical terms here explained before attempting to go further.

We have elsewhere, in the course on Chemistry, received some idea of how compounds such as a salt of copper or zinc are built up of elements combined in definite proportions, and we have further learnt that these salts are many of them capable of dissolving in water, to form a solution. We have also, when studying electricity and electrical measurements, learnt many of the properties of electricity—how it is generated by a dynamo, or a battery, and, moreover, how it flows along metallic conductors, and how its rate of flow can be measured in *amperes*, and its pressure or "electromotive force" can be measured in *volts*, and its quantity in *coulombs*, and the resistance which a conducting body presents to its passage can be measured in *ohms*. We have seen that electricity can flow through a metal like copper or silver without changing its character; but now we come to a different class of conductors—namely, complicated salts of metals dissolved in water. Such liquids are conductors of electricity, and often good conductors too, but they differ essentially from metals in that electricity in passing through them *decomposes them or splits them up into their original constituents in exact proportion to the amount of electricity passed.* No action takes place in the body of the liquid, but only at the points or *surfaces at which the electric current enters and leaves the liquid.* The accompanying diagram clearly shows all the essential features of an apparatus which is made to bring about this process called *electrolysis* [1]. First we have a liquid, or *electrolyte*, consisting, for instance, of copper sulphate in water; this is contained in an *electrolytic tank*, made of glass, earthenware, or other material. The electric current is first conducted by wires to the *anode*, through which it enters the electrolyte, passes to the *cathode*, and out again by a wire back to the generator. The other details depicted will become clearer presently. We would repeat that the *deposition* of metals and gases *takes place only on the surface of the cathode and anode* respectively, which together are called *electrodes*, a fact which must be carefully borne in mind.



1. PRINCIPLE OF AN ELECTROLYTIC SYSTEM

Electrolytic Reactions. With the diagram constantly before us, let us imagine that the tank is of glass, the electrolyte a solution of copper chloride in dilute hydrochloric acid, and the electrodes sheets of platinum. Then imagine that a current of electricity is passing in the direction of the arrows, and let us see what takes place. Copper chloride (cuprous chloride) is a salt built up of the metal copper and the gas chlorine in the proportion of 63 parts of copper to 35 parts of chlorine (by weight). Now, as the current travels *it carries with it to the*

surface of the cathode some of the copper atoms, which become attached to the cathode and form a deposit or coating of copper upon the surface of the platinum, which thus becomes "electroplated" with copper. We might continue this process by *passing a definite quantity of electricity through* until, say, 63 oz. of copper had been thus deposited. Now think of the 35 oz. of chlorine with which the 63 oz. of copper were originally combined—what has become of them? Chlorine is a *non-metal*, and non-metals, instead of travelling *with* the electric current, travel in the reverse direction—namely, *against* it, so the *chlorine has been taken to the surface of the anode*. As, however, chlorine is a gas when in a free state, it cannot deposit upon the anode as does the copper upon the cathode, but it forms there a cloud of small bubbles, which rise up to the surface of the liquid and escape into the air. Metals, like copper, are therefore said to be *deposited upon* the cathode, and non-metals, like chlorine, to be *evolved from* the anode. There is only one metal which is a gas when free, and that is *hydrogen*, which, although it goes to the cathode like other metals, is evolved as a gas there and escapes. Acids, like hydrochloric acid, are really salts of the metal hydrogen, and when electrolysed evolve the gaseous hydrogen at the cathode.

Once more look at our diagram [**1**] and imagine the electrolyte to be a solution of *sulphate of copper*, and the electrodes sheets of metallic copper. Again pass the electric current as before. Copper is plated on to the copper cathode, and simply makes it grow thicker, but at the anode the non-metals sulphur and oxygen, which went to build up the copper sulphate, are deposited, and these are together liberated. If the anode were of platinum they would escape, but as it is now of copper they are able to attack or eat it away, re-forming sulphate of copper again, and keeping up the supply of copper in the bath. The copper anode is thus eaten at exactly the same rate as the copper cathode grows thicker, and the process might be continued until the whole of the copper anode had been transferred to the cathode.

These effects are called *electrolytic reactions;* those in which the deposited substance is actually liberated and separated are called *primary reactions*, and those in which it recombines with the liquid are called *secondary reactions*. Instances of both will be given later on, both in commercial use.

Electro-chemical and Electro-thermic Reactions. We have now gained an insight into what is known as the *electrolysis of solutions*, but there is another way of rendering a dry crystalline non-conducting salt capable of taking the form of a liquid and undergoing electrolysis. Common table salt is a substance built up of a metal called *sodium* and the gas *chlorine*. It may be dissolved in water and electrolysed like copper chloride, although with a somewhat different result, as will be seen later. But if it be placed in a fireclay crucible and raised to a red heat it melts to a clear liquid, which looks like red-hot water, and is capable of being electrolysed or split up like a solution. As a rule, great practical difficulties attend experiments upon melted salts, but where it is possible to conduct the operation the process is extremely simple and perfect. Processes of this kind are classed under the heading of *the electrolysis of fused salts*.

Now for a few moments let us forget *true electrolytic* reactions, as we have come to understand them, and think of purely *chemical* processes, like the smelting of iron in an ordinary blast furnace. In this iron ore and coal are mingled in a white-hot furnace; the oxygen of the ore unites with the carbon of the coal or coke, escapes into the air as carbonic acid gas, and the metallic iron runs down in a molten condition to the bottom of the furnace hearth and is drawn off and cast into ingots. Much more coke is used than is needed for the separation of the iron; the excess of coke is put in simply to burn, and make the furnace and its charge *white hot*. If we were to mix the ore with only sufficient coke for its separation and not enough to make it burn when lighted, *and then* heat this mixture by some other means, we should obtain the desired result, separating the iron. We have already learnt in the course on Electricity that when a large current of electricity passes through indifferent conductors it heats them. If, therefore, we were to pour an electric current through such a charge we should raise it to a very high temperature, and thus effect the *reduction* or *separation* of the iron. Such reactions are known as *electro-thermic* or *electric-furnace reactions*, and may be produced by an alternating or a direct current as they are independent of electrolytic reactions, and, although the conductors conveying the current into and out of the charge are called *electrodes*, they are not electrodes quite in the sense in which we have so far regarded them. The high temperature of the electric furnace is capable of converting ordinary carbon into graphite. This fact has been largely made use of by the Acheson Graphite Co. in America in the manufacture of "graphitised" carbons, which are specially suitable for use as anodes for all kinds of electrochemical work, being less readily corroded and eaten away.

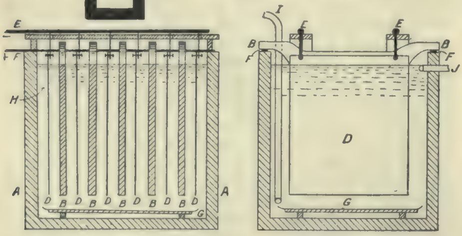
If electricity be forced through a gas by applying it at a high electric potential, a phenomenon akin to electrolysis is observed. We shall deal with this more fully when discussing ozone and nitric acid, but in the meanwhile it may be observed that, although coming under the head of Electro-Chemistry, it should not be regarded as really electrolytic.

Copper Refining. This metal is found in the form of minerals, which are smelted down in blast furnaces, and then refined by a complicated and difficult process in a furnace. As many as seven operations are involved, but even then the copper produced contains many injurious impurities, among them being iron, tin, lead, antimony, and other substances. In addition to these impurities it nearly always contains a small proportion of the precious metals silver and gold. All these impurities render the crude copper useless for drawing into wire or rolling into sheet. Moreover, it is highly desirable that the silver and gold locked up in the crude copper should be separated in order that they may be sold as such. The process by which the whole of the copper of the world is now refined and the precious metals separated is an electrolytic one.

The refining works consist, first, of a foundry for casting the crude copper into large plates to be used as *anodes*; secondly, there is a large room or shed in which stand long rows of large wooden or slate watertight boxes or "vats," in which the refining takes place; thirdly, there is a generating house for the production of the electric current; it contains one or more dynamos, producing a direct current, and driven by steam engines or by water power. Fourthly, it has offices and laboratories, in which the gold and silver bullion is finally separated and refined.

The *electrolyte* in the tanks consists of a solution of *copper sulphate* and sulphuric acid in water. The *cathodes* are thin rolled sheets of *pure copper*. Each

tank contains several thick crude copper anodes and thin pure copper cathodes suspended alternately, side by side, about 1 in. apart in the electrolyte. All the anodes are connected to the positive, and all the cathodes to the negative main, and when the current flows the copper from the crude anode is dissolved, and deposited on to the cathode, which process is continued until the anode becomes thin and weak and the cathode thick and strong; this may require several days or even weeks to accomplish. *The gold and silver and other impurities, instead of dissolving with the copper at the anode, form into a mud or deposit, and fall to the bottom of the vat.* This mud is collected and smelted down for its gold and



2. COPPER-REFINING VAT

silver, while the copper, which passes over to the cathode, is pure and free from all the impurities originally present in the crude metal.

Figure 2 shows a diagram of an electrolytic copper-refining tank. A = the tank; BB = crude copper anodes, which have been previously cast in the anode mould C; DD are the thin pure copper cathodes; EE = the negative leads connected to the suspended cathodes; FF = the positive leads on which the anodes rest; G is a tray for catching the anode mud which falls from the surfaces of the anodes; H is the electrolyte, consisting of a solution of copper sulphate and sulphuric acid in water, the circulation of which is maintained by the inlet and outlet tubes, I and J.

Commercial Aspect of Copper Refining. In actual practice the refining of copper is carried out on an exceedingly large scale. The Anaconda Copper Company's works, using the Thofehrn system, is one of the largest in the world, and is capable of refining 150 tons of copper per day. The electric current is produced by four large dynamos driven by engines of 900-horse power each, and another driven by a 400-horse power engine, which can be switched on to any part of the refinery in case of breakdown in one of the larger engines. In addition to this, 50-horse power is used to light the works by electricity, and 30-horse power is needed to pump the electrolyte from tank to tank in order to maintain efficient circulation.

The tanks are arranged in rows in two large buildings, each having a floor space of 6,500 sq. yd., and containing 600 electrolytic tanks, each tank being 8 ft. 3 in. long by 4 ft. 7 in. wide by 3 ft. 3 in. deep. They are made of wood and lined with lead; 16 copper cathode rods and 15 anode rods run the length of the tanks, connected to the positive electric main and the negative main respectively, and on these hang the copper anodes and cathodes themselves.

Each vat requires an electric pressure of about ½ volt, and as 200 vats are connected in series, the total electric pressure required would be 100 volts. The vats are arranged on an incline, and the electrolyte flows from one to the other, being finally pumped back again; this ensures a good circulation. In practice copper ("blister") containing about 110 oz. of silver and ⅛ oz. of gold per ton, and some arsenic, iron, lead, and other impurities, is refined. The current used is about 15 amperes to each square foot of cathode plate surface, as this enables a clean, thick, smooth deposit of copper to be obtained. The total cost of the process is said to be about £3 per ton of copper refined.

The same principle as this is also largely used to electroplate cycle frames, teapots, etc., with copper before the nickel or silver is added. It has also been applied, but only with indifferent success, to the extraction of copper direct from its ores.

We may here, too, mention the electrolytic skinning of tinned iron scrap, which is largely done in Germany. The tin scrap is made the anode in a hot solution of caustic soda in which the tin becomes dissolved and re-deposited on to a cathode, while the iron itself, remaining insoluble, is taken out, washed, and beaten into coherent masses under the hammer.

Lead. The ordinary method of extracting this metal from its mineral galena is fairly simple, and consists of two operations conducted in a furnace in which coke is used to supply the heat. Impure lead is thus reduced from the ore containing many of the impurities, like antimony, copper, iron, etc., which render it too hard for working, and also all the silver and perhaps gold present in the original mineral. It is then refined by melting, and air is allowed to play upon its molten surface, which turns the impurities into a dross so that they may be removed. The silver and gold are then taken out by a laborious and expensive method, by which they are recovered and the lead refined.

An electro-chemical process to compete with this has to produce pure lead and silver in a more direct way, and at less expense.

Knowing the force with which the lead and sulphur are combined in the mineral galena, it is possible to calculate the amount of energy that would be needed to separate, say, one ton of lead, and if this calculation is made it shows that in theory an electrical method of extraction would be much cheaper than the ordinary one at present used. But the practical difficulties are enormous, and up to the present time no electrical process has been developed which can compete successfully with the old methods, although much promise is shown for the future. Broadly speaking, it has been attempted in two ways. The first method is to convert the galena into some form of lead salt that will dissolve in water and then *electrolyse* the solution so that the lead is deposited upon the cathode. A process of this kind was once tried by Keith in America. The galena was melted and cast into anodes (galena is one of the few minerals that will conduct electricity freely). Then thin pure sheet-lead cathodes were made, and the electrolysis was performed in an electrolyte consisting of a solution of acetate of lead. The action was like copper refining. The impurities were thrown down as a mud and contained the precious metals. The pure lead was deposited as a spongy mass on the cathode, which was afterwards melted down. This represents only one of the many attempts in this direction, but it has also been tried by a "fused electrolysis" method, described later.

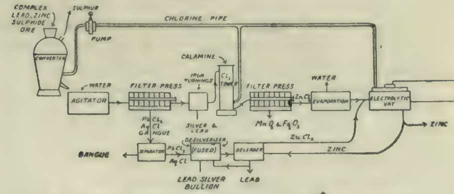
Zinc. Zinc is a somewhat more common metal than lead in nature. It is found as a brown, shiny mineral called *blende*, which consists of zinc and sulphur, and also as an oxide and carbonate, both of

which are white. Silver is seldom found with it, but the impurities, iron and arsenic, are almost invariably present. The extraction of this metal from its ores is simple, but exceedingly expensive and wasteful. It is put into retorts with coke and distilled by the heat of enormous external furnaces. The coal and coke bill is excessive, and the constant wear of the retorts terrific. Theoretically the cost of extraction is overwhelmingly in favour of electrical methods, but the practical difficulties, as in the case of lead, are very great; so much so, that so far no electro-chemical process has been able to take the place of the ordinary distillation method of extraction, although a process invented by Hoepfner, and worked by Brunner, Mond & Co. in England, is in operation for the refining of crude zinc and the production of a specially pure kind.

But in spite of the great difficulties which beset the electro-chemist when experimenting with processes for the reduction of zinc there is very great promise of its ultimate success, so that along with lead it may lay claim to a place of importance in the not far distant future. Both the wet and the dry methods, described in the early part of this course, have been applied with some considerable degree of success to zinc extraction. All sorts of acids have been used to dissolve the zinc ore so as to obtain its solution in water, but the most general way of attaining this end is to heat the blende in a furnace through which is allowed to flow a current of hot air, so that the zinc blende is burned or "roasted" into a form in which it will dissolve in water. Having thus obtained it as a solution in water, it is placed into an electrolytic tank and electrolysed with a cathode of pure zinc on to which the zinc deposits, and an anode of carbon or lead, which, not being acted upon by the solution, simply allows bubbles of oxygen to escape from its surface.

If a zinc ore be dissolved in hydrochloric acid, a salt of the metal, consisting of zinc and chlorine (chloride of zinc), is formed, which may be melted in the manner described in a previous paragraph and electrolysed in a fused or melted condition with a zinc cathode and a carbon anode. Zinc is deposited at the cathode and the gas chlorine in a heated condition escapes at the surface of the carbon anode.

Lead and Zinc Sulphide Ores. Lead sulphide (galena) and zinc sulphide (blende), as we have seen, can be treated individually by ordinary chemical processes so that their respective metals are extracted in a more or less pure condition, but it may here be pointed out that if these two minerals are mixed together they would so far



3. DIAGRAM OF PHŒNIX LEAD-ZINC-SILVER-SULPHIDE PROCESS

interfere with one another as to make it practically impossible to treat them at all. As a matter of fact, the bulk of the lead and zinc and a large proportion of the silver existing in Nature occur in this amazingly mixed up way, and have managed so far almost to baffle the chemist completely, so that he cannot find any way in which to treat the mixture in order to get out of it the lead, the zinc, and the silver. In theory, however—that is, calculating from the known amount of energy which would be required to separate the metals—an electrical process has an enormous margin of profit, so that much attention has been paid to this subject. Many wet processes have from time to time been introduced, but nearly all have been abandoned.

In **3** is shown in diagrammatic form the "Phœnix" process invented by James Swinburne. The ore, which is first crushed to a fine powder, is placed in a refractory receptacle, called a *converter*. Into this is forced red-hot chlorine gas obtained from a subsequent operation. This converts the sulphides into chlorides, and frees the sulphur. The "pudge" thus obtained is dissolved in water, and filter-pressed, separating the gangue (or sand) and lead and silver chlorides. A mechanical separator then takes out the gangue, and the chlorides of lead and silver are dried and melted with lead to take out the silver. The lead chloride left is then treated with zinc to reduce the lead. The solution from the first filter-press (mainly zinc chloride) is run through iron turnings to precipitate any lead and silver from solution by the substitution method already described; it is then treated with cold chlorine in presence of calamine (zinc carbonate ore) which precipitates manganese and iron as oxides. These are filter-pressed out, and the pure zinc chloride solution is evaporated and electrolysed in a melted condition, using anodes of carbon and a cathode of melted zinc. Thus all the lead, zinc, silver, sulphur, sand, and impurities are recovered separately from the original complex ore.

Gold. The winning and extraction of gold from its ores is essentially a different problem from the winning of any other metal. We have seen that lead-bearing and copper-bearing minerals almost always contain gold in more or less quantity, and that this gold is reduced or smelted along with the metal, and has to be extracted by some means from the metal itelf in the subsequent course of refining. But the bulk of the gold of which the world has become possessed has been extracted, not from the ores of other metals, but from clean rocks or river beds, in which it is contained in small quantities, mixed in with the rock or gravel, *in the metallic state*, and not combined to form a mineral. It is not a case of reduction, but it is a case of winning it, or searching for the tiny particles, like needles in a haystack. The latter illustration is, moreover, suggestive; for if we were given a haystack containing, say, iron filings, and asked to extract them, we should all probably suggest that the stack be first ground to chaff, and that the chaff be blown past a magnetic pole, when the iron filings would stick to the magnet and the chaff be blown away. And so, if we are given a rock containing gold dust, we should grind it to powder and blow it over something corresponding to a magnet. But gold is not attracted to a magnet, so another device is used. Plates of copper *amalgamated* or coated with mercury are substituted; and to these the small gold particles adhere, and become dissolved. The powdered ore is passed over these amalgamated plates with water and the useless "tailings" are carried away. To win gold particles from the gravel beds of rivers a more simple process is used. The gravel is simply taken and placed in a "batea," or "Chinaman's hat," and swilled round with water. The gold, being heavier than the gravel, collects in the bottom of the batea, and is saved. But neither of these processes can be satisfactorily

applied to gold rock ores containing *very* small quantities of embedded gold. A more delicate and efficient mode, known as the *cyanide process*, is used, which consists of leaching, or soaking, the pulverised ore in a weak solution of cyanide of potassium. In this solution the gold dissolves, the liquid is then drawn off, and the gold is extracted from the cyanide solution by contact with zinc shavings, which reduce it to metallic gold.

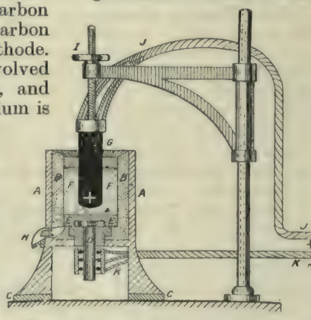
Electricity in Gold Extraction. Electricity has not by any means revolutionised the gold winning industry, but it has gradually stepped into a position of great utility, from which it is not likely to be removed. Electricity has taken no part in washing, but it has found a use in amalgamation in the Molloy process. As already explained, copper plates are amalgamated, or coated with mercury. Over these the ore and water flow, and the gold particles are caught up by the mercury and retained. In practice, however, the surface of the mercury soon becomes "sick" or dull, and loses its power of catching the gold. Originally a little metallic sodium was added to the mercury, and the action of this metal kept the surface of the mercury bright and clean. Molloy discovered that if a little sulphate of sodium (Glauber's salt) be added to the water which carries the gold ore in suspension, and a current of electricity be passed through so as to make the mercury surface itself the *cathode*, a small amount of sodium is deposited into the mercury and, as already explained, keeps the mercury from "sickening." But electricity has taken a more important place in the cyanide extraction process. A very weak solution of cyanide of potassium is, theoretically, needed to dissolve the gold from an average ore, say one part in 20,000; but in practice it is found necessary to use about one part in 2,000. Having dissolved the gold, the next step is to treat the solution with zinc shavings to re-precipitate and recover it again, and in order that the zinc may do this efficiently, it is necessary to use cyanide of a strength of about one part in 200; this is actually used on the Rand in South Africa, but as cyanide is expensive, and a large proportion of the solution is lost, this is a disadvantage. If, however, the gold be dissolved in one part cyanide in 2,000 it may be efficiently deposited by electricity, and on account of the weaker solution which it is thus necessary to use, much less cyanide is lost. The Siemens-Halske, and other processes based on this principle, are gaining headway in South Africa and New Zealand. The solution of gold in cyanide is used as electrolyte, and is made to pass slowly between iron anodes and lead cathodes, the gold being plated on to the cathode in the usual way. This cathode, when sufficiently plated with gold, is melted down and the gold recovered by the usual process of "cupellation."

The electro-metallurgy of silver has been sufficiently dealt with when discussing the refining of copper, lead, and other metals with which it is generally associated in nature.

Aluminium. These metals are reduced from their ores *exclusively* by methods involving the electrolysis of a molten electrolyte in a crucible. They both occur universally, in almost every rock and soil, but the only minerals directly available for their reduction are *cryolite* from Greenland, a compound of aluminium and fluorine, *bauxite*, a compound of aluminium and oxygen, and *carnallite*, a compound of magnesium and chlorine. Both these metals have a very great affinity for the elements with which they are combined, and great energy is required to separate them.

Aluminium is extracted largely in Scotland by the British Aluminium Company at the Falls of Foyers, in America, and in Switzerland, at the Falls of the Rhine. The first part of the process is purely chemical and consists in purifying the cryolite and bauxite and freeing them from iron and other impurities, so as to obtain the pure fluoride and oxide of aluminium. The two representative processes are those of Héroult and Hall. In the former the aluminium oxide is melted in a crucible, which requires a great heat; the heating is done, not by a fire, but by the electric current itself, which, in its passage through the alumina (aluminium oxide) raises it to sufficient temperature. Molten aluminium metal lying in the bottom of the crucible is connected to the negative pole of the electric generator, and forms the cathode on to which the reduced aluminium from the alumina deposits, and the anode consists of a rod or rods of graphite or carbon, which is consumed by the oxygen liberated from the aluminium oxide. This oxygen, however, instead of escaping as such, unites with the carbon anode to form carbonic acid. The Hall process is similar, but instead of molten alumina the electrolyte consists of molten cryolite, in which is dissolved some alumina. The cryolite itself is not decomposed or used up, but only the alumina, and in this respect the process is comparable to that of Héroult. As the aluminium is formed it is tapped from the bottom and cast into ingots and fresh alumina is added to the top of the crucible. About 8 to 10 horse-power hours are required to deposit 1 lb. of aluminium and to maintain the temperature at about 950° C.

Magnesium. Magnesium is extracted in a very similar manner. Purified *carnallite* is fused in a crucible by means of a gas furnace and is electrolysed, using a carbon anode, and a carbon or metal cathode. Chlorine is evolved at the anode, and melted magnesium is liberated at the cathode, which, being lighter than the fused electrolyte, floats to its surface. Magnesium is manufactured on a large scale in Germany by the Magnesium and Aluminium Fabrik. Neither aluminium nor magnesium can be deposited from solution in the ordinary way, but only from fused electrolytes.



4. ALUMINIUM EXTRACTION APPARATUS

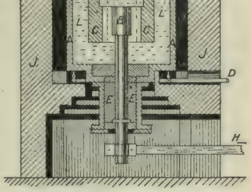
The aluminium extraction apparatus as originally used at the Falls of the Rhine is shown in **4**. A is an iron crucible lined with charcoal B, resting on an insulating stand C. A metallic conductor, D, passes through the bottom, causing the molten aluminium, E, to formthe cathode. The electrolyte, F, is a molten solution of alumina in cryolite. G is the carbon anode from which oxygen and carbonic acid are evolved. H is the tap hole for the aluminium; I the gear for adjusting the height of the anode; J the positive and K the negative electric cables. The necessary temperature is maintained by the high current-density of the electric current.

Sodium and Potassium. To those who are not familiar with these metals a word or two

describing them may not be out of place. They are very similar in general properties, of the hardness of a stiff wax, being easily cut with a penknife, of a yellowish colour, and "highly electropositive"—that is, they have an exceptionally great affinity for non-metals like chlorine, oxygen, etc. So great is this affinity that they will replace all the more ordinary metals when brought into contact with their salts. Thus, when sodium is brought into contact with water it violently replaces and liberates the hydrogen (which often catches fire through the violence of the reaction), forming with the oxygen of the water the compound known as *caustic soda*, or hydrated sodium oxide. Potassium is even more powerful than sodium, but, in general, brings about the same changes, forming with water *caustic potash*. Sodium and potassium, as well as a similar metal called *calcium* (the base of lime, chalk, etc.) are so common as to form a large proportion of the earth's crust, but the purest and most promising source of the former metal is *sodium chloride*, or common salt.

Practical Difficulties. Salt, if melted in a fireclay crucible, may be electrolysed at a red heat, using a carbon anode and copper or iron cathode. Hot chlorine gas is evolved at the anode and escapes; at the cathode melted sodium forms, and being lighter than the melted salt it floats to the surface. In principle this is simplicity itself, but in practice it has baffled electro-chemists completely. The practical difficulties in the way are so enormous that although much attention has been given for many years to this branch of chemistry, no successful method has ever been invented for the electrolysis of melted salt direct for the manufacture of sodium metal. The chief difficulty is that the sodium when once formed re-dissolves before it can be collected. To overcome this Ashcroft has patented a process in which melted lead is used as cathode; into this the deposited sodium travels, and becomes dissolved or alloyed, and a constant circulation of the melted lead is maintained by means of a rotating electromagnet placed below the crucible. After the lead has become charged with sodium it is placed in another crucible containing fused caustic soda.

In this the lead is made the anode and there is a cathode of iron. When the current passes the lead gives up its sodium, but does not itself dissolve, and this sodium passes through the fused caustic soda, and is deposited on to the iron cathode, where it may be collected without danger of being re-dissolved. In this process chlorine and sodium are produced and the salt, which is very cheap, is the only substance used up. At present, sodium is exclusively made by the Castner process from caustic soda, which is more expensive than salt. The caustic is melted in an iron crucible by a gas flame. The action is rather complicated, but the result is simple; iron electrodes are used, and at the anode oxygen gas is liberated, while at the cathode, hydrogen gas and *metallic sodium* are liberated, and the latter is ladled out and saved. Potassium, for which there is only a very limited demand, is also made in a similar way, from *caustic potash*.



5. CASTNER'S SODIUM EXTRACTION APPARATUS

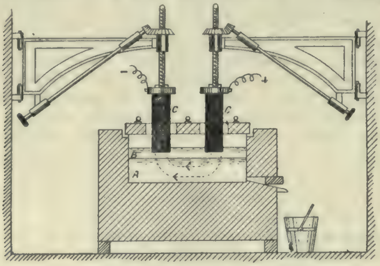
Castner's apparatus for the electrolytic separation of sodium from melted caustic soda is shown in **5**. A is an iron melting-pot kept hot by a ring gas burner D. B is the cathode entering from the bottom and insulated from the pot by solidified caustic at E. CC is a circular iron anode. M is an iron hood (with lid) supporting a wire gauze curtain (shown by dotted line), and G and H are the leads connected to the anode and cathode respectively. JJ is a masonry support for the whole apparatus and serves as a furnace with flue, K. The whole apparatus is full of molten caustic soda, LL, and when the electric current flows oxygen is evolved at the anode, and escapes through an outlet or through the loosely fitting top. At the cathode, B, hydrogen (which bubbles up, and escapes through the loosely fitting lid, F) and metallic sodium are formed. The sodium floats up into the hood, M, as shown at P, and is withdrawn by a ladle. The various parts of the apparatus (as at R) are kept insulated by asbestos card (not shown).

Iron and Steel. Iron is found in Nature most commonly combined with oxygen and sulphur. With oxygen, which form is familiar as "rust," it occurs as *magnetic iron ore*, *hæmatite*, and *specular ore*, and with sulphur as *iron pyrites*. The oxides serve as the source from which our iron and steel are reduced, and the processes by which they are manufactured, although exceedingly complex in detail, are nevertheless commonly understood in principle. All that is necessary to extract iron is to heat the ores to a white heat in a blast furnace with charcoal or coke, when the carbonic oxide produced by the partial burning of part of the coke combines with the oxygen of the ore to form carbonic acid, which escapes up the chimney of the furnace, while the iron runs in a molten condition to the bottom of the furnace. But however pure the ore may be it always contains a large proportion of infusible earthy matter, and in order to render this fluid in the furnace *fluxes* have to be added, usually in the form of carbonate of iron ("*spathic iron ore*") which forms a suboxide of iron in the furnace capable of combining with the earthy matter to form a liquid "slag." Steel is only iron in which is dissolved a small proportion of carbon from the coke, and is produced by varying the conditions in the smelting operation, or by subsequent treatment of the iron.

The main object of introducing electricity into the smelting of iron is simply this: in an ordinary blast furnace charge, besides the coke necessary for the chemical reduction of the iron, there has to be added sufficient excess to burn and supply the heat of the blast furnace itself. Now, it is obvious that in some localities, where fuel is very expensive, and where electricity is very cheap, as, for instance, in the neighbourhood of a large waterfall, it might be advantageous to supply this extra heat by electrical energy, and, moreover, as the whole operation would be much more under control, and the losses of heat from radiation, flue gases, etc., reduced, it would stand a fair chance of economical competition. Upon the strength of arguments of this kind many metallurgists have devoted a considerable amount of energy to the problem, and several processes and types of furnace have been developed. Iron and steel are often alloyed with other metals, such as tungsten, chromium, etc., and the electric furnace method has given greater facilities for this during the operation of reduction. Dr. Héroult has paid special attention to the refining of crude iron and production of steel in the electric furnace [**7**], which has been previously reduced in the ordinary blast furnace, in an electric furnace, or in a

combination of the two. There is some promise of this method taking an important place in the future of the metallurgy of iron.

Figure **6** shows a diagrammatic section of Héroult's crude iron refining furnace. Crude iron, A, and slag, B, are run in from an ordinary blast furnace while still in a molten state. CC are carbon electrodes, which dip only into the slag, but the path of the current through the metal (as shown by the dotted



6. SECTION OF HÉROULT'S CRUDE IRON-REFINING FURNACE

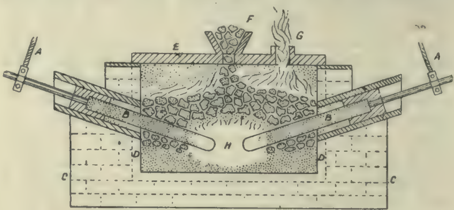
lines) keeps the whole mass hot. Electric energy thus supplies the requisite heat while the refining and steel production are regulated by the addition of the reagents used in the ordinary methods of crucible and other steel.

Carbides, "Carborundum." The enormously high temperature which it is possible to obtain in the electric furnace (3,500° C., as against only 1,800° C. in the hottest coke furnace) has enabled many new chemical substances to be produced which it has been impossible to obtain even in an oxyhydrogen furnace. We have already seen that if iron oxide be heated with coke or carbon in the electric furnace iron is reduced to the metallic state. If, however, a large excess of carbon be used in the charge, and the furnace be raised to a very bright blue heat, the metallic iron at first reduced recombines with the excess of carbon to form a body called a carbide. But iron is by no means the only metal which behaves in the same manner. If we take the oxides of any of the following metals—aluminium, barium, cæsium, calcium, cerium, chromium, lanthanum, magnesium, manganese, molybdenum, potassium, sodium, strontium, thorium, titanium, tungsten, uranium, or zirconium; or the non-metals boron, selenium or silicon—and heat them with a large excess of carbon in an electric furnace, carbides, varying greatly in their general properties and the proportions of carbon contained in them, are produced. Space does not permit of detailing the many interesting properties of these carbides, but a few of their most important characteristics may be mentioned. Silicon carbide which is now more generally known under the name *carborundum*, is a black crystalline substance, extremely hard; in fact, in this respect, it approaches very nearly to diamond, and on account of this fact it is largely used as an abrasive for polishing and grinding. It is an inert body, and water has no action upon it whatever, and it is difficult to dissolve in any acid. Carborundum is manufactured on a large scale in America from a mixture of pure sand (silicon oxide, or "silica") and coke. Boron carbide is a very similar body, and is even harder than carborundum, but as silicon is a much more common, and consequently a less valuable, substance than boron, the former is able to compete in commercial use.

For the production of these carbides, and for all electric furnace reactions, an alternating current may be used; unlike true *electrolytic* reactions, they do not require a direct current.

Figure **7** is a diagram of a simple form of electric furnace. The current, which may be alternating or direct, and conducted in either direction, is conveyed by the leads, AA, to the carbon "electrodes," BB. CC is the firebrick body of the furnace, with a magnesia or other refractory lining, DD. E is the furnace cover, with hopper, F, for the introduction of the charge, and outlet, G, for the escape of the carbonic oxide or other gaseous product evolved in the operation. When beginning, the electrodes are pushed together in contact, and are gradually drawn apart, when an electric *arc* is formed and the centre of the charge begins to become white hot, as shown at H. This process may be continued until the whole charge is melted and the temperature is extremely high.

Calcium Carbide. Many of the carbides are energetically acted upon when brought into contact with water, when they decompose the water, the metal combining with its oxygen and the carbon with its hydrogen, evolving the latter in the form of a combustible gas. Aluminium carbide evolves methane; manganese, cerium, thorium, and uranium carbides evolve mixtures of methane, acetylene, and hydrogen; while barium, lanthanum, strontium, and calcium carbides evolve acetylene in a nearly pure state. As far back as 1836 the great chemist



7. ELECTRIC FURNACE

Davy found that the residue obtained in the extraction of potassium, which was really a carbide, evolved an evil-smelling combustible gas when brought into contact with water; and later, in 1862, the chemist Wöhler actually produced calcium carbide, and, from it, acetylene. It was not, however, until a few years ago that the commercial value of calcium carbide was discovered, and it was made possible to manufacture it on a large scale in the electric furnace. The property of calcium carbide to decompose water and to evolve a nearly pure form of acetylene is now known to everybody, as is also the extreme power which this gas has of emitting light when burned in air.

Calcium carbide is manufactured on a large scale by mixing together well-burnt lime, which is calcium oxide, and a pure form of coke or powdered carbon. The charge is then introduced into the electric furnace and heated up to a very high temperature. The carbon electrodes of the furnace may be arranged in several ways. One method is to bring them together over the top of the charge, then separate them so as to form an arc, which radiates its heat on to the charge and thus melts it. Another method is to fill in a line between the separated electrodes with coarsely broken carbon, which, upon the first passage of the current, becomes hot and melts the charge. A third plan of starting is to push the electrodes down into the charge until their ends meet, and then, as soon as the electric current

begins, gradually to separate them so that the arc formed fuses the part of the charge between their ends. When the electrodes become fully separated the whole charge is melted. The furnaces are generally constructed of firebrick, and lined with a refractory material. A charge of about a ton of lime and three-quarters of a ton of powdered carbon is introduced, which produces about one ton of calcium carbide. The amount of electrical energy required varies, but is approximately 300 to 500 electrical horse power for 12 hours. The manufacture of calcium carbide is carried on chiefly in the States.

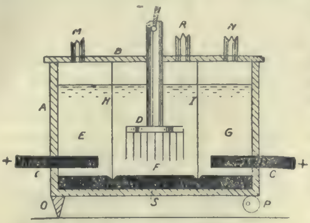
Secondary Reactions. When describing "electrolytic reactions" in the early part of this course it was pointed out that, although the metallic atoms travelled with the current, and the non-metallic atoms travelled in the reverse direction to the current until they reached the surfaces of the cathode and anode respectively, they are not always deposited there in a coherent form. In the case of the metal hydrogen it is evolved as a gas and escapes into the air, and in the case of the non-metals chlorine and oxygen, they, too, are evolved as gases and escape. These reactions are termed *primary*, bcause the primary or original atom or atoms which are carried to the electrodes are there separated. It is very frequent, however, that the primary atoms, or *ions*, are not actually separated, but that they recombine at the very moment of liberation with the electrolyte. Such reactions are termed *secondary*, and are somewhat more difficult to understand fully. A good example of this kind of reaction is given by the electrolysis of common salt, which consists of an impure form of sodium chloride. If it be melted and electrolysed in a crucible at a red heat, sodium and chlorine are evolved and separated; but if it is dissolved in water, and the solution is electrolysed, the action is completely different. The sodium travels to the cathode, but at the moment of its liberation it is snatched up by the water of the electrolyte, and, combining with it, forms caustic soda. At the anode the action varies according to circumstances; chlorine travels there, and at the beginning it is evolved and escapes. But if the electrolyte is allowed to circulate freely, so as to bring some of the caustic soda formed at the cathode into the immediate neighbourhood of the anode, the chlorine, instead of escaping, will combine with the caustic soda to form hypochlorite and chlorite of sodium.

Under these circumstances, secondary reactions are taking place at both electrodes. It is obvious from what has been said that if it is desired to manufacture chlorine gas and caustic soda the circulation of the electrolyte between the anode and cathode sides must be prevented; while, if it is desired to manufacture hypochlorites and chlorite of sodium, the caustic soda liquor formed at the cathode should be allowed to flow gently towards the anode side. These results are obtained by the use of what is called a *porous partition*, or diaphragm, made of some such material as asbestos fibre or a porous porcelain or baked clay. A slab of this is inserted between the anode and cathode, thus dividing the vat into anode and cathode compartments. Through this the liquids permeate, but do not freely mingle or circulate, and through the electrolyte imbedded in its pores the electric current can freely travel. The use of this arrangement will become clearer presently.

Caustic Soda. The raw material is common salt, or sodium chloride, and the problem is to electrolyse this so as to obtain caustic soda and chlorine gas. The salt is dissolved in water, and is electrolysed with carbon anodes and iron cathodes. Chlorine is evolved at the anode, and is led away over damp slaked lime, where it forms bleaching powder, and at the cathode caustic soda is produced.

The chlorine thus produced frequently contains some carbonic acid gas, formed by the oxydation of the carbon anodes. This may be eliminated by passing the chlorine over a preliminary batch of lime or bleach, which becomes gradually converted into carbonate. In this way the carbonic acid is kept from the bulk of the bleaching powder, which it would dilute if allowed access. The solution of caustic, which always contains a certain amount of salt, is led away, evaporated, and finally melted down, when the salt floats as a scum to the surface and is removed; the caustic is then cast into sticks, and along with the bleaching powder is sold.

A process originally worked on this simple plan was developed by Holland and Richardson, and worked by the Electro-Chemical Company in Lancashire. The cathodes were of wire gauze, and the anodes of carbon from the gas retort. Another, known as the Hargreaves-Bird process, and worked by the Electrolytic Alkali Company in England, was somewhat similar, but the gauze, which was placed outside a porous partition, and on to which steam and carbonic acid were blown, formed the cathode. By this method chlorine and sodium carbonate (washing soda) were manufactured.

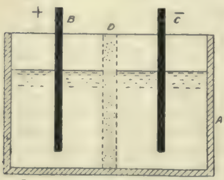


8. CASTNER-KELLNER CAUSTIC SODA APPARATUS

The Castner-Kellner Process. In 8 is shown a diagram of the principle of the Castner-Kellner process for the production of caustic soda from common salt in solution, which is run at Runcorn, in Cheshire, on a large scale; this process makes use of an "intermediate electrode" of mercury, and its action will be readily understood by reference to the diagram. A is the vat with cover B and carbon anodes CC. D is an iron grid cathode. The tank is divided by the two partitions H and I into three compartments E, F, G. E and G contain a solution of common salt in water, and F contains (upon starting) ordinary water. The bottom of the tank is covered with a layer of mercury, S, and the partitions H and I do not extend to the bottom of the tank, but down only to just below the surface of the mercury. The liquids are thus separated, but the mercury is continuous. The electric current enters the salt solution in E and G, and evolves chlorine, which escapes through the outlets N, M. It then enters the surface of the mercury,' depositing metallic sodium into it. The tank is pivoted at O, and rocked by the eccentric P, thus circulating the mercury into the compartment F, where the current leaves the mercury and enters the water, leaving by the cathode D. Gaseous hydrogen is evolved at the cathode, and escapes by the outlet R. The sodium in the mercury, and not the mercury itself, thus dissolves in the water and forms a pure solution of caustic soda. The electric pressure required is from 2·5 to 3·5 volts. Sodium hypochlorite is a body consisting of sodium, chlorine, and oxygen, and is largely used in the bleaching industries, and in

disinfecting, for the reason that it readily gives up hypochlorous acid, a very powerful oxydising or bleaching agent. Potassium chlorate is a substance composed of the same elements but more stable. It consists of potassium, chlorine, and oxygen, and is largely used in the manufacture of explosives, fireworks, and matches, on account of its power of rapidly giving up its oxgyen to other bodies with which it is mixed.

Hypochlorites and Chlorates. The principle upon which the manufacture of these is based has already been hinted at. In the case of sodium hypochlorite a solution of common salt is electrolysed with a metallic platinum anode and an iron or copper cathode. Between these electrodes is inserted a porous diaphragm, usually made of asbestos fibre stretched on a wooden frame. At the cathode caustic soda forms, and as the level on this side of the diaphragm is higher than on the anode side, the caustic soda gradually circulates by gravity towards the anode compartment. As it percolates through the diaphragm its place is taken by fresh salt solution gradually added from above. This caustic then finds its way to the anode, where it meets with the chlorine, and, as already explained, is converted into sodium hypochlorite, and is drawn off for bleaching purposes. The manufacture of potassium chlorate is almost exactly similar, but there is this essential difference. If chlorine gas is allowed to act on caustic soda *in the cold* sodium hypochlorite is formed; but if the temperature of the solution be raised beyond about 50° C., instead of hypochlorite, chlorate of sodium is formed. This fact is taken advantage of in the parallel case of potash chlorate making. The raw material is potassium chloride, and at the cathode caustic potash is formed, while, as this percolates through the porous diaphragm into the anode compartment, and meets with the chlorine of the anode, chlorate, and not hypochlorite, of potash is produced. The potassium chlorate is then separated by crystallisation and is sold. The manufacture of potassium chlorate is now almost entirely electrolytic, and one of the original and largest manufactories is at Vallorbes, in Switzerland. There are other substances made on a similar principle, but these are the most important and most highly developed.

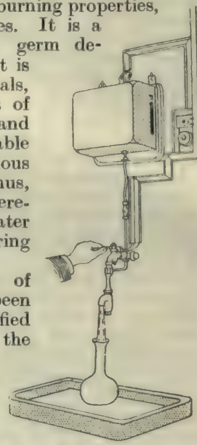


9. APPARATUS FOR MAKING HYPOCHLORITES AND CHLORATES

Figure **9** is a diagram of a simple electrolytic apparatus demonstrating the principle by which caustic soda or potash chlorate or hypochlorite is manufactured from a solution of chloride. AA is a vat; B and C are platinum anode and cathode respectively, and D is a porous partition of unglazed earthenware or canvas. If a solution of sodium chloride (salt) be the electrolyte, chlorine is evolved at B, and hydrogen and caustic soda at C. If, however, potassium chloride be continuously run in at C, caustic potash is formed, and this, upon percolating through the partition to B, and meeting with the chlorine, forms potassium hypochlorite. If the whole operation be conducted at a temperature near to boiling, potassium chlorate, instead of hypochlorite, is formed.

Ozone and Nitric Acid. Atmospheric air consists of a mixture of oxygen and nitrogen. The atoms of oxygen are naturally grouped together in *pairs*, and these pairs are called *molecules*. The only difference between oxygen and ozone is that the latter consists of oxygen atoms grouped together in sets of three. On the principle that "two is company and three is none," the odd atom is always eligible for pairing with the first attractive companion. Ozone, then, may be considered an unstable form of oxygen, which is more ready to combine with other bodies, or to "oxydise" them, than is ordinary oxygen. Ozone, or rather "ozonised air," is produced by passing a silent high-pressure electric discharge through ordinary air, some of the atoms of oxygen become electrified, and are attracted to the unelectrified molecules.

The cause of its presence near the sea is probably the evaporation of the sea spray as it breaks upon the shore, for direct electrification is not the only means by which air may become ozonised. On account of its oxydising or burning properties, ozone has found many uses. It is a powerful disinfectant and germ destroyer, and on this account is coming into use in hospitals, and even in public places of amusement, in hotels, and private houses. It is capable of destroying many noxious germs, such as anthrax, typhus, and cholera bacilli, and is therefore useful for purifying water for drinking, and in rendering sewage water harmless.


10. THE "OTTO" ELECTRIC OZONISER FOR STERILISING WATER

The healing properties of ozone have undoubtedly been exploited by those unqualified to understand them, but the fact that the medical profession are seriously regarding it proves its genuine usefulness in many cases.

Small and large ozonising plants are now being constructed by the Lahmeyer Electrical Co., Ltd., of London, a small plant designed for domestic use being shown in **10**. They consist essentially of a transformer and condenser for transforming the pressure of the electric mains to a pressure varying from 3,500 to 7,000 volts, and the ozoniser itself, which has electrodes presenting many points, and opposed across glass or other insulators.

If, instead of a silent discharge, powerful electric sparks be passed through the air, nitric peroxide is formed by the union of the atmospheric oxygen and nitrogen. The gas, when dissolved in water, forms nitrous and nitric acids, and the manufacture of the latter substance by electricity promises to be an important industry in the near future.

WATER-SOFTENING AND WASTE PRODUCTS

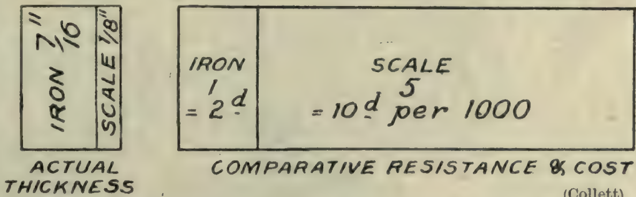
Soft Waters for Domestic Use. In places where the water as ordinarily supplied is hard, and both wasteful and unpleasant to use, people would do well to remember that prevention is better than cure, and turn their attention to other and more suitable sources of supply. Why not use rain-water? A simple calculation will show that the water from the roof of a house, if caught and utilised, would be sufficient for a large proportion, and in some cases for the whole of the requirements of the inhabitants. In most cases such water goes to waste.

Removal of Impurities. After a shower, the first water from the roof of a house carries with it a quantity of soot, black, birdlime, etc., which would spoil the colour of the rest, and give to it other undesirable qualities. By an ingenious contrivance, such as the Roberts Rain-water Separator [11 and 12], the dirty portion, consisting of the first washings from the roof, is automatically run to waste, and the rest, consisting of the clear and good water, is stored for domestic use. Such apparatus can be purchased from £3 to £6. The saving to the household due to the absence of scale in kitchen boiler and kettle will quickly pay for the cost of installation. Moreover, such water is by many people much preferred for washing and for baths, and it goes without saying that the saving in soap alone amounts to something substantial per annum.

COST OF FUEL WASTE BY SCALE.

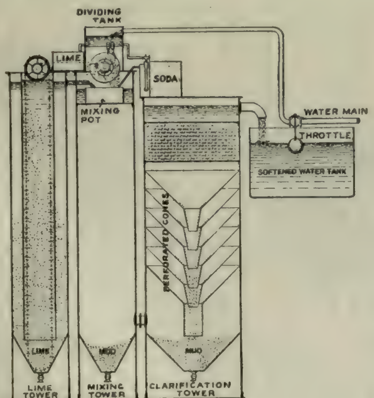
	10°/o	15°/o	20°/o	25°/o
	Cost. d.	Cost. d.	Cost. d.	Cost. d.
With coal at 8s. per ton ..	4·8	7·2	9·6	12
,, ,, 10s. ,, ..	6·0	9·0	12·0	15
,, ,, 12s. ,, ..	7·2	10·8	14·3	18
,, ,, 14s. ,, ..	8·4	12·6	16·8	21
,, ,, 16s. ,, ..	9·8	14·4	19·2	24
,, ,, 18s. ,, ..	10·8	16·2	21·6	27
,, ,, 20s. ,, ..	12·0	18·0	24·0	30

For small villa houses and cottages a water butt should be placed to catch the rain-water. A rum puncheon of 100 to 120 gal. capacity should be used where possible, and even a 40 gal. cask is not to be despised.

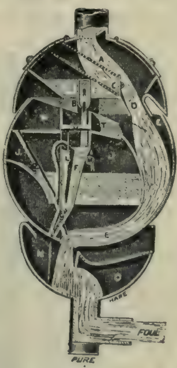


(Collett)

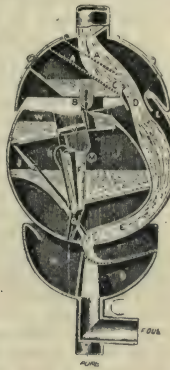
Soft Water by Distillation. Soft water is prepared by distillation from sea-water. Extremely efficient appliances for this purpose render such water available for industrial and domestic purposes in seaside places where other water cannot be obtained at a reasonable cost. Of course, such apparatus is indispensable on board ship on long voyages. By such a process water is not only freed from its mineral constituents, but it is also rendered sterile.



13. DIAGRAM OF STANHOPE WATER SOFTENER
(Stanhope Water Engineering Co. Ltd.)



11. ROBERTS RAIN-WATER SEPARATOR
(Impure water passing to waste)



12. ROBERTS RAIN-WATER SEPARATOR
(Pure water passing to storage)

Scale in Boilers from Hard Waters. But the chief purpose for which water is softened is for steam raising. Here, softening is not a matter of convenience, but of necessity, to ensure both safety and economy.

As Harold Collett stated: "The waste of fuel occasioned by scale and blowing out must be remembered when considering the cost of a water supply, from what ever source. The cost of the water before it enters the boiler is a mere nothing compared to the cost of evaporating it. Many waters would be dear at 1d. per 1,000 gal., others are cheap at 1s." Hard water wastes in fuel for every 1,000 gal., according to the thickness of scale in the boiler, as shown in the figures above.

Water-softening by Chemicals. The hardness of water may be described as of two kinds —*temporary* and *permanent*—the former so called because it can be removed by prolonged boiling.

Temporary hardness is due to the presence in the water of bicarbonates—that is to say, lime and magnesia combined in certain proportions with carbonic acid. Bicarbonate of lime is so called because it consists of two equivalents of carbonic acid and one equivalent of lime; it is soluble in water, and is contained in most natural waters. On the other hand, carbonate of lime—that is, one equivalent of carbonic acid combined with one equivalent of lime—is insoluble in water, and therefore, if formed, separates out from solution. If, therefore, the bicarbonates can be converted into carbonates they will come out of solution as a deposit, which can be removed, and the temporary hardness so got rid of. It is obvious from the foregoing that the bicarbonates can be converted into carbonates by removing one equivalent of carbonic acid, and this can be done in two ways—either by boiling the water for some time, causing part of the carbonic acid gas to be driven off, by which the bicarbonates are converted into carbonates, or,

secondly, by adding slaked lime—that is, pure hydrate of lime or calcium hydroxide—in the right quantity. One part of carbonic acid in the bicarbonate is taken up by this fresh lime, so that the soluble bicarbonates disappear with formation of insoluble carbonates.

Permanent hardness, like temporary hardness, is caused by the presence of certain salts in solution in the water, of which the more important are calcium sulphate (sulphate of lime), calcium chloride, magnesium sulphate, and magnesium chloride. All four compounds affect the test for hardness already mentioned. Calcium sulphate gives rise to the hardest scale, but can be removed by adding soda ash (carbonate of soda) to the water. What is known to chemists as "double decomposition" takes place. Sulphuric acid leaves the lime and combines with the soda, whereby are formed sulphate of soda, which does not form scale and carbonate of lime, which is removed by subsidence or filtration. The insolubility of carbonate of lime is the prime factor in the change.

14. STANHOPE CLARIFYING TOWER
(Stanhope Engineering Co., Ltd.)

Water Softened by Heating. There are many forms of apparatus used for water softening, all of which may be said to have been evolved from the same simple process first used by Dr. Clark, of Aberdeen, which merely consisted in adding clear lime-water to hard water, containing bicarbonate of lime or magnesia in solution. This, by combining with one half of the carbonic acid, throws down a double precipitate of chalk. Prior to Clark's process water was softened without any plant at all. Clark's process is expressed by the equation

$$\underset{\text{Bicarbonate of lime (soluble)}}{CaH_2(CO_3)_2} + \underset{\text{Lime}}{Ca(OH)_2} = \underset{\text{Chalk (insoluble)}}{2CaCO_3} + 2H_2O$$

The softening of water by heating is expressed by the simple equation

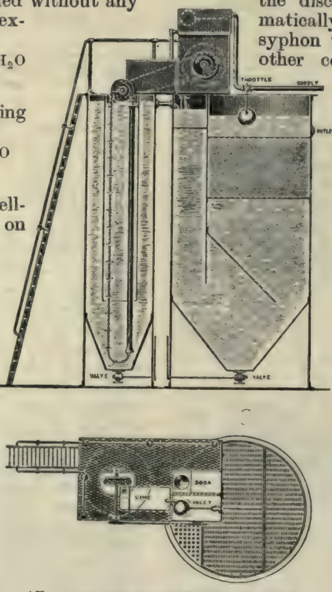
$$\underset{\text{Bicarbonate of lime (soluble)}}{CaH_2(CO_3)_2} = \underset{\text{Chalk (insoluble)}}{CaCO_3} + \underset{\text{Carbon dioxide}}{CO_2} + H_2O$$

Upon this principle one or two well-known processes are based, notably on the Continent. Thus we have Scham's apparatus, in which water is forced into a dome, passing as a fine rain through perforated grids, mounted so that the holes do not come vertically over one another, the waste steam from the boiler passing between and heating the water sufficiently on its downward passage so as to cause it to deposit its lime salts before it passes into the boiler. We have also Howatson's softener, a cylindrical reservoir containing plates arranged in stages in a manner so that the water travels in a zigzag fashion until it reaches the bottom, when it is softened, a ball-cock at the bottom regulating the inflow at the top. For further information regarding such processes see "Industrial Use of Water," by H. de la Coux (Scott, Greenwood & Co.).

The Stanhope Softener. In the Stanhope Water Softening Process [13 and 14] we have illustrated an effective means of removing the sediment by gravitation. The water from the main, which is automatically controlled by means of the throttle, enters the top tank just in proportion as it is removed from the softened water tank. In its flow through the dividing tank and the mixing-pot it drives a water-wheel, which in turn drives a mechanical stirring apparatus for the lime-water. A continuous stream of clear saturated lime-water passes to the mixing-pot, together with the water to be softened and the soda in proportion required. It then passes down the mixing tower, where some sediment is deposited, and up the clarifying tower [14], where the rest of the deposit is caught by settlement on the cones and drops to the bottom through the spouts. The softened and clarified water emerges from the top. The process is entirely automatic, and as long as the apparatus is charged, and periodically blown off, it can be kept going indefinitely.

The Collet-Stanhope Water Softener is somewhat different from the foregoing, the accompanying illustration being sufficient to show in what respect it differs [15].

The Criton Softener. In the Criton water softener [16] the hard water is admitted to a tank divided by a partition into two unequal portions; the larger of these, which contains a syphon, is called the *syphon tank*, and the smaller the *measurer*. The top of the partition is 2 in. below the level at which the syphon begins to discharge. When the level of the water in both compartments has reached the discharge point the syphon automatically discharges the contents of the syphon tank into the mixer, leaving the other compartment brim full. In the syphon tank is a float, which, as it descends, lifts, by means of a lever, a valve at the bottom of the measurer, and permits the accurately measured quantity of water to run into the "limer," displacing an equal quantity of clear lime-water, which overflows into the mixer. During its passage upwards in the "limer" the water passes through a bed of slaked lime, and on reaching the top has become saturated lime-water. The bed of lime is kept stirred up by an agitator worked from the float of the syphon tank.



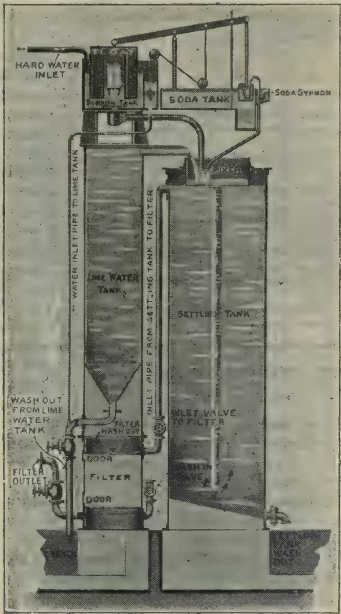
15. COLLET-STANHOPE WATER SOFTENER
(Stanhope Engineering Co., Ltd.)

The soda tank contains a solution of soda of given strength. To the end of the lever worked by the float in the syphon tank is attached a bucket. When the float rises this bucket dips into a sump in the bottom of a soda tank, and when the float descends the bucket is raised brim full. As soon as it is clear of the soda tank it is brought into contact with a syphon, which discharges the contents of the bucket into the mixture.

It will thus be seen that accurately measured quantities of hard water, lime-water, and soda

solution are discharged together into the mixer at every discharge of the syphon. The capacities of the two reagent measures can be easily and rapidly varied when required. The discharge of the reagents is exactly dependent on the quantity of water to be softened. If this is reduced the syphon tank fills fewer times per hour, and consequently the number of times the reagent measures, discharge is reduced in the same proportion.

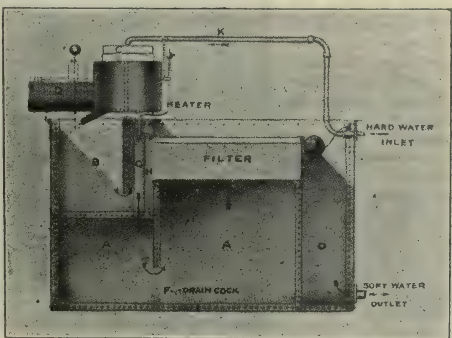
The discharges from the hard water syphon tank, and from the lime and soda tanks, all meet at the same time and at the same place—namely, the mixer, and are violently dashed together, thus ensuring an immediate and thorough mixture. From the mixer the treated water passes through a down pipe to the bottom of the settling tank, whence it steadily flows upwards, depositing in its progress the heaviest of the suspended matters caused by the action of the softening process. From here it passes through the filter, emerging at "filter outlet" soft and bright. The filter is cleaned without the removal of the filtering medium merely by opening and closing certain valves. The lime tank is recharged with lime daily, and the spent lime drawn off. In order to keep the plant running it is sufficient to have the attention of one man for one hour per day.



16. "CRITON" WATER SOFTENER
(Pulsometer Engineering Co., Ltd.)

The Bruun-Lowener Softener.

In the square type of the Bruun-Lowener water softener [17] the water to be treated is led through the pipe K into one of the chambers of the oscillating receiver, C. When this chamber is filled the centre of gravity is moved, and the receiver tips over, pouring its contents into the intermediate tank, B, below, at the same time bringing the other chamber of the receiver underneath the orifice of the pipe K. On the side of the oscillating receiver is fixed a semicircular tank, D, containing the chemicals (lime and soda ash or caustic soda), and in the bottom of this tank a valve is fitted, through which the chemicals fall into the chamber B. To the receiver is fixed a system of levers which at every oscillation actuates the valve in the bottom of the tank D. The lift of the valve can be regulated by the small nuts fixed on the valve spindle, so that a given quantity of chemicals can, by this arrangement, be mixed with the water.

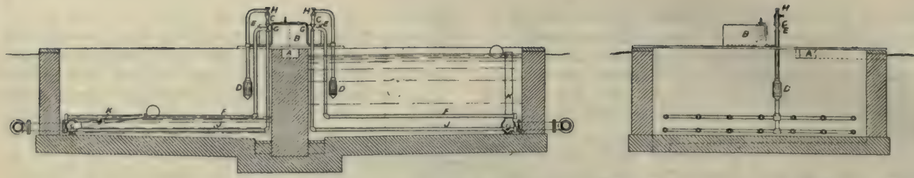


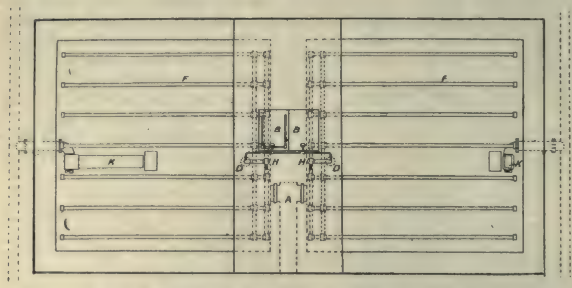
17. BRUUN-LOWENER WATER SOFTENER
(Lassen & Hijort)

The lime milk in this apparatus has a strength of 10 per cent.; clear saturated lime-water has on an average a strength of 0·13 per cent.; the lime milk, therefore, has a strength of nearly 100 times that of the lime-water, making it possible to reduce the size of the tanks containing the lime in the same proportion. A further advantage of using lime milk is that a certain quantity of freshly burnt lime is mixed with a certain quantity of water, a solution being obtained, the strength of which is always known. In order to keep the lime milk in constant motion an agitator is fixed inside the semicircular vessel containing the chemicals, and the oscillation of the receiver C is utilised for driving the agitator. The mixture of water and chemicals passes from B into the heating chamber, H, which is provided with a steam nozzle for either live or exhaust steam. The water is generally heated to a temperature of about 150° F. to facilitate the precipitation of the foreign matters. However, where steam is not available the water can, of course, be treated cold. From the heating chamber the water passes through the bypass pipe, G, into the settling tank, A, where the precipitation takes place. Before leaving the tank the water is filtered through the filter, which is made of wood wool, packed tightly between two rows of wooden bars. The filter can easily be taken out and cleaned by removing the top bars, and the filtering material can be used over and over again, after having been properly cleaned. A sludge cock, F, is provided for drawing off the deposit. The softened and purified water coming from the filter flows into the storage tank O, at the end of the softener, and is drawn therefrom. The flow of water to the oscillating receiver is regulated by means of a high-pressure float valve, fixed on the pipe K, through which the water passes.

Settling Accelerated by Agitating.

Not long after Dr. Clark's process had been installed an obvious improvement suggested itself, the discovery of which may have been a pure accident. In Clark's process the precipitate is allowed merely to settle in large concrete or iron tanks, and the clear water is drawn off from the top. The precipitation is comparatively slow, but if the deposit at the bottom is stirred up each time the settlement of fresh deposits is much accelerated, on account of the heavier crystals entangling and carrying down the lighter ones. In early forms of plant, as soon as a charge was introduced into the tank it was customary to stir up the sediment each time with a paddle or mechanical stirrer. This principle is carried out in a scientific manner in plant constructed by





18. PATENT EFFLUENT WATER I URIFIER
(Mather & Platt, Ltd., Manche ter)

Messrs. Mather & Platt, of Manchester [18], which can be understood by reference to the figures: A, Effluent water inlet; B, tank for dissolving chemicals; C, blower for air and mixing chemicals; D, perforated rose; G, three-way tap; H, air tap on blower; F and J, perforated pipes for air; K, floating discharge pipe. The blower not only disturbs the sediment, but mixes the chemicals. A great saving in time of settling is established, and consequently a greater output of softened water is obtained. Furthermore, the plant is suitable not only for ordinary softening, but for purification. Some waters which are not amenable to carbonate of soda and lime treatment alone can be treated by the use of these chemicals in conjunction with alum. Water so softened is also rendered organically purer, as careful trials have proved.

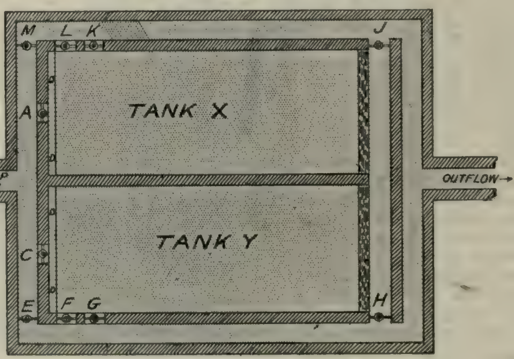
The Removal of Grease from Water. The removal of lime and magnesia salts, although important, is not more so than the removal of grease, as there is no doubt that the presence of grease in feed water has been frequently the cause of the collapse of boiler tubes and other serious casualties. The removal of grease from exhaust steam is effected by oil separators, such as Baker's [20], of which there are many sizes and patterns to meet the various requirements.

Treatment of Effluents. The purification of effluents from different works has largely been forced upon the manufacturers by legislation, but of later years the products resulting from such purification have been found to be of industrial importance, and therefore in such cases, even if restrictions were removed, the manufacturers would still continue the processes of purification for their own advantage. An important case in point is the recovery of waste liquors from esparto and wood boiling [see Paper-making].

Where mere subsidence will carry down the particles and leave the effluent clear, and sufficiently pure, settling tanks, such as were used in the early days, are still employed. In such cases the effluent flowed in succession zigzag fashion through a series of concrete tanks over cills or partitions. The first tanks, of course, received the heavier deposit, and the tanks were arranged so that one or two at a time could be dispensed with while the deposit was being removed; but ground space will not always permit a system of this kind. Moreover, the quantity of effluent capable of being dealt with is limited to the settling capacity of the tanks, and if great variations take place in quality and quantity of effluent, the treatment is likely to be unsatisfactory.

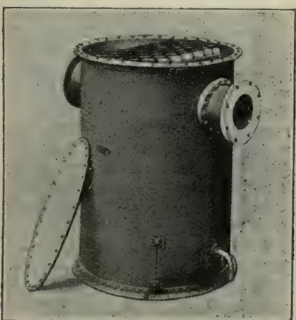
It must be admitted that the Rivers Commissioners are very reasonable in their requirements, and so long as manufacturers show that they are exercising their best endeavours to fulfil such requirements they are not unduly harassed; but upon the manufacturer is placed the onus of devising a scheme for the treatment of his effluent, and it necessitates a great deal of ingenuity on his part to choose between the many well-known processes so frequently brought to his notice.

We have known cases where troublesome effluents have been treated at very small outlay by digging sumps where the ground is impermeable, and causing the water to flow over a succession of terraces like those arranged for watercress beds. Such primitive appliances at times do more to satisfy requirements than complex filters. Figure **19** shows an arrangement of settling tanks.

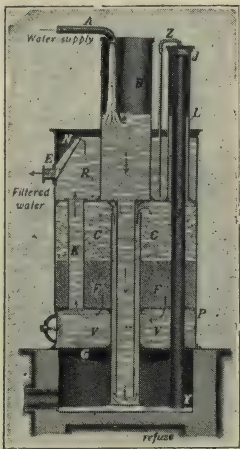


19. TANKS FOR PURIFICATION WITH ALUMINOFERRIC
(Peter Spence & Sons)

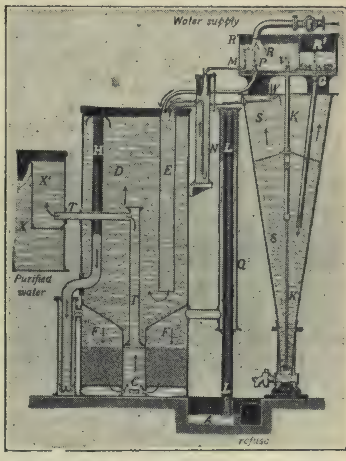
"Reisert" Automatic Self-cleaning Filter. This [21] is used for clarifying turbid or muddy water for industrial purposes. The water to be filtered is received into the chamber B, and flows downwards, following the course of the arrows into the chamber C, and so reaches the filter bed, F, through which it percolates, leaving the mud, etc., on the upper side of the bed. The filtered water is received into chamber V, and finds its way upwards *viâ* pipe K into chamber R, and finally overflows the diaphragm, N, into the filtered-water outlet, E. Obviously, the rate of filtration will vary with the state of the filter bed and the head of water in B. As the filter bed fouls and the resistance to the flow of the water increases, the water level in B rises and establishes a corresponding level in the pipe L., which, it will be observed, is in connection with C, Inside this annular pipe, L, is another pipe, S, which extends from nearly the top of L right through the filter bed and receiver V to the waste water channel G, forming the base of the filter. As the water rises in L, in sympathy with B, there presently arrives a time when it overflows at J, and so forms a syphon. The current through the filter is thus rapidly reversed, the water in R flowing back through K and upwards through the filter bed, the deposit on the filter being thoroughly disturbed and carried into the waste channel, G. The chamber R is proportioned to contain sufficient water to effect this cleansing operation thoroughly, and as this chamber empties, air enters and destroys the action of the syphon, and the cleansing ceases. The filter then resumes its normal working. The cleansing operation is repeated as often as the state of the filter requires, and is entirely automatic.



20. THE BAKER OIL SEPARATOR



21. REISERT AUTOMATIC SELF-CLEANING FILTER (Royles, Ltd.)



22. REISERT AUTOMATIC SOFTENER (Royles, Ltd.)

The same system is used in conjunction with the water softener [22]. This latter is peculiar in its construction, and different from any of the foregoing. The lime saturator, S, is cone-shaped. The charge of slaked lime is inserted through tank R′ once daily.

By a constant uniform water supply from the distributing tank, R, which is conducted downwards through the central pipe, K, through micrometer valve V, the lime paste at the bottom is stirred up and thoroughly impregnated, so that it rises at first partly with the water, until the rapidity of the rising water diminishes so much, owing to the upward widening shape of the saturator, that the undissolved lime particles are no longer able to follow, so that the saturated lime-water, clarified, then leaves the saturator, S, at the top, through the pipe W, and is carried away into the reaction chamber, D, by way of the mixing pipe, E. The soda apparatus is charged with strong soda solution once daily, and being much heavier than water, it remains at the bottom.

The water flowing from the distributing tank, R, through the small micrometer valve M—which is adjusted in accordance with the amount of soda required—into the soda chamber, N, remains always on the surface of the soda solution (no mixing occurs) and displaces the same, it being carried through the small pipe from the bottom upwards, and into the mixing pipe, E, and finally into the reaction chamber, D. The softening takes place in D, and the water, after softening, passes down through the filter, F, up into the tank X′, where it overflows into the tank. N is the syphon for flushing the filter. In all respects it acts in a similar way to the cleansing filter already described [21].

The "Torrent" Filter. This represents a type with which we have not dealt. It is extremely simple, and costs very little for upkeep. The great feature of this filter is that the filtering medium is cleansed and revivified by introducing for a few minutes, at intervals of about ten hours, a jet of air under high pressure produced by the aid of a steam blower, and at the same time admitting a reverse current of water. The violent agitation so produced causes the whole of the filtering medium and contained impurities to boil up, as seen in 23. The particles of dirt are washed away and discharged through the outlet, leaving the filtering medium clean. The medium never requires to be replaced by fresh, and what little there is lost through the dirt is easily made up by the addition from time to time of small quantities. The filtering medium is chosen to suit the requirements of the particular water which is to be treated. There are no mechanical moving parts to get out of order.

Filtration. For laboratory work special filters are constructed, the simplest, perhaps, being the Kitasatos porous tubes in addition to which we have the Chamberland porous filter [25], which can be mounted in metal tube with stopcock to fit

a water supply. There are also the Massen filter candles with porcelain heads [26], and the well-known Klein laboratory filter, fitted with Pasteur-Chamberland filter tube [24].

For domestic work we have very much the same kind of contrivance working under pressure. In some of them dirt is quickly removed by the reversal of the current of water. Numerous other filters and water softeners, both for domestic and manufacturing purposes, have been invented, and are in use, but it has been possible to consider only some of the typical processes here. One of the most simple and effective for the clarification of an ordinary mill effluent is that recommended by Peter Spence, to be employed in conjunction with aluminoferric, which is now so much used for the purpose.

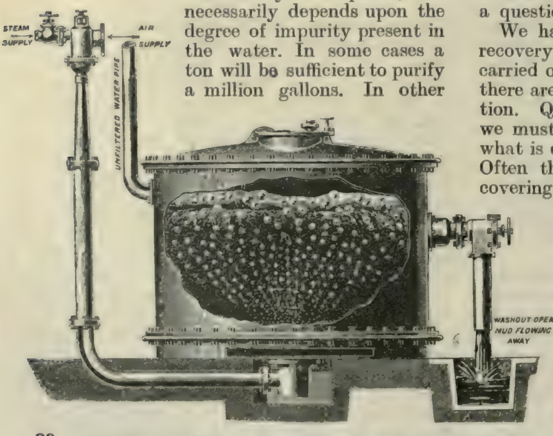
24. KLEIN'S LABORATORY FILTER

How to Apply Aluminoferric. Figure 19 gives a general idea of the method of using aluminoferric, also of a system of settling tanks which, we think, may with advantage be adopted by many manufacturers for purifying their waste water. BB represents the box or cage containing the aluminoferric standing in the channel or conduit. PP represents a series of baffle plates to insure the aluminoferric being thoroughly mixed before flowing into the tanks. The two tanks shown may be used in two different ways as may best suit the special circumstances of each manufacturer.

They may be used independently by opening A and C and closing E and M. The treated water will thus pass into both tanks, where precipitation will take place, and, when full, will flow over the sill at the end, and, H and J being open, the clarified water will pass away into the outfall.

Alternately, C and E and M being closed, the treated water will flow into tank X, and passing forward will overflow into the channel at the end, and H and J being also closed, the water will flow into tank Y, and F and G being open, will flow into the side channel and pass away into the outflow as in the first instance. Or the working as described may be reversed by closing A and M and opening K and L.

With regard to the quantity of aluminoferric which may be required, this necessarily depends upon the degree of impurity present in the water. In some cases a ton will be sufficient to purify a million gallons. In other instances, where the water is highly impure, experience shows that it may be necessary to use a quantity equal to two tons per million gallons.



23. TORRENT FILTER IN PROCESS OF BEING CLEANED
(Pulsometer Engineering Co., Ltd.)

The price of the aluminoferric may be taken at £2 15s. per ton, in four-ton lots, delivered at railway station within, say, 50 miles of Manchester or Goole. The superior results obtained by this process have enabled manufacturers in many instances to utilise the clarified water for manufacturing purposes, and where this has been done, it has been found that the purification is accomplished practically without expense.

Recovery of Fibres. Objections are raised to effluents from mills containing fibrous particles, which may be harmless in themselves but will spoil the appearance of the stream. They are frequently collected for economic reasons and used again in the manufacture.

Perhaps the simplest appliance for catching fibres from effluent is an ordinary "save-all," which consists of a revolving cylinder slightly tapering and revolving slowly on a horizontal axis and covered with fine wire gauze. The water passes in at the small end and drains through, the fibre is caught and discharged at the other end of the drum. The well-known Fullner Separator, which takes the fibres out by a process of settlement, has now become a part of the general equipment of a mill. After this clarification process, the fibre collected is used again in the manufacture.

We do not profess to deal with the subject of sewage purification [see page 4547], but there is no hard and fast line dividing such purification from that of mill effluents, because the latter includes many cases which require to be submitted to similar treatment to sewage, as, in addition to removing chemical impurities, it becomes frequently necessary to destroy organic contamination. We have, therefore, practically all the methods of sewage purification employed in conjunction with existing works on effluents, even to the bacterial process.

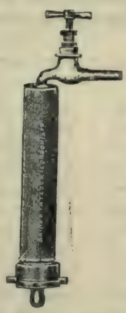
Can Waste Products be Utilised? There are many so-called waste products which are now turned to useful account, and therefore no longer regarded as such. In fact, as we all know, there should be no such thing as a waste product. Whether or not it can be utilised becomes merely a question of £ s. d.

We have to inquire under what conditions the recovery process and utilisation of waste can be carried out economically. To answer this question there are several factors to be taken into consideration. Quite apart from the nature of the products we must know the quantity to be treated, and, what is even more important, the state of dilution. Often the quantity is insufficient to pay for recovering, even although excellent processes may be elsewhere in operation. If waste liquors are to be treated they must not be too dilute; thus it pays to recover the alkali from esparto liquors but not from rag liquors, as the latter are usually too dilute and the cost of evaporation would be too great. It might, however, pay where esparto and rag liquors are treated together.

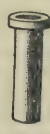
As another illustration, we recently examined a quantity of waste fibrous material with a view to utilising it or finding a suitable outlet. We found that the material yielded, on dry distillation,

a high percentage of acetic acid and wood spirit; but although some hundred tons were available per annum, the quantity was too small for a plant to be constructed to work it economically. In such a case the only alternative is to look around for similar waste products which could be treated in the same plant.

Slag and Mineral Refuse. Considerations such as we have outlined above apply to practically all waste products. Take, for instance, the case of blast furnace slag. Enormous quantities of this material have been accumulating, and may be seen as huge mounds or heaps by the side of the furnaces. Numerous projects have been put in hand for utilising this waste, but consider some of the initial difficulties. In many parts furnaces are scattered up and down the country in twos or threes, and to utilise the slag economically it must be worked up on the spot. We will suppose plant and machinery is installed, what is to happen when that particular heap of slag is exhausted, and it costs too much to bring it from a distance? Nevertheless, slag is being employed for a number of purposes. In many parts it is used as a road metal, although not very suitable for this purpose. It is also used for making bricks, paving slabs, wall copings, ornamental blocks, etc., with the addition of lime and cement as bonding agents. Other waste materials, such as slate refuse, clinkers from destructors, stone chippings, and even sand may be similarly treated. These materials are first fed into a heavy revolving grinding mill, and reduced to fine powder by passing through screens and returning the coarse stuff to be reground, as described in the manufacture of ordinary bricks [see page 1278]. The resulting ground material is then measured out with the "bond," whether lime or cement, in the correct proportions, and delivered into a mixer under a spray of water, and thence the material passes to the mixing pan—a machine similar to, but lighter than, the grinding mill, and, when reduced to the correct consistency, it is conveyed to the brick-making machine. The moulded bricks are dried either in the usual manner by air hardening or by a more rapid process. By heating the bricks in an autoclave [27] under 120 lb. steam pressure, they can be hardened and ready for the market in 24 hours.



25. CHAMBERLAND POROUS FILTER



26. MASSEN'S FILTER CANDLE

Blast furnace slag and Portland cement resemble one another in composition, and successful attempts have been made to prepare cement from this material, but in spite of all inventions there is plenty of slag left for the chemist to work upon.

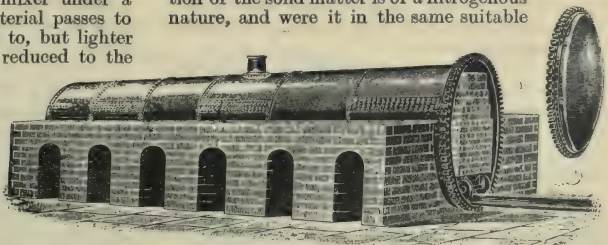
Other Examples. Numerous examples of the utilisation of waste products will be found in studying any industrial process. Thus, the glue-maker depends on the waste pieces of hide or leather clippings and the waste bones from the slaughter-house or dust heap [see page 5357]. The manufacturer of animal black uses waste animal refuse of all sorts. The farmer feeds his stock on cotton-seed or linseed cake, from which the valuable oil has been extracted [see Cattle Foods], on bran and pollard from the flour-mill [see page 3078], on brewers' grains [see Brewing], and numerous other so-called "waste products," of which not an ounce is really wasted.

Sometimes the waste is employed again in the same factory in which it was originally produced, as in the case of metals melted down for use again, or in the "regeneration" of waste rubber. Perhaps coal-tar is the most striking instance of what was once but can no longer be regarded as waste [see page 5461].

One of the most troublesome sources of contamination to streams is the effluent from flannel mills which is derived from the processes used in washing wool. Wool always contains a proportion of fatty substances, the greater part of which, however, resemble fat only in appearance, and not in chemical properties. These consist of a body termed *cholesterine*, belonging to the class of substances known to chemists as *alcohols*. Chemically, wool fat is more difficult to decompose than ordinary fats, and, in consequence, hangs about and contaminates any water or stream into which it finds its way. As potash is used in wool-washing, it pays to evaporate the waste liquors instead of allowing them to become an effluent, and, after concentration, to ignite them, when the potassium is recovered in the form of potassium carbonate. The ash is lixiviated, and the liquor used over again for wool-washing.

One of the waste products for which no really satisfactory use has been found consists of the sulphite liquors remaining over after the preparation of wood pulp [see Paper-making]. These liquors have been worked up for the separation of sizing materials, but without much commercial success. The latest attempts lie in the direction of the production of cattle foods, but reliable data are not yet to hand.

Perhaps one of the most difficult of all problems is the utilisation of town refuse. A large proportion of the solid matter is of a nitrogenous nature, and were it in the same suitable condition as it is sometimes found in country districts, it would prove a most valuable manure. Unfortunately, in large towns and cities it becomes diluted with such large volumes of water that the economical separation of the more valuable constituents becomes one of the most difficult problems with which we are faced. On the other hand, we cannot but view with concern the large quantities of combined nitrogen which are constantly being removed from the soil and deposited in the sea. The solid matter of town refuse is now frequently burnt, combustion taking place in special furnaces or destructors. In many towns the heat so produced is utilised for steam-raising.



27. JOHNSON'S AUTOCLAVE, OR HARDENING CHAMBER
(William Johnson & Sons, Leeds)

Continued

A GUIDE TO DENTAL STUDY

How the Student Qualifies for Practice. Course of Study and Examinations. The Student in the Hospital. The Higher Degrees

THE medical and dental professions are both under the control of the General Medical Council, appointed by Act of Parliament, whose headquarters are at 299, Oxford Street, London, W. The duties of the Council are concerned principally with the registration of doctors and dentists, such registration being held to confer the legal qualification to practise the profession of medicine or dentistry, as the case may be. There are a number of universities and colleges which conduct examinations and confer diplomas or licences in accordance with the result of these examinations, and the Council, subject to the approval of the Privy Council, determines what licence so conferred shall be accepted as evidence that the holder is possessed of adequate knowledge and skill. The Council bases its decision in each case upon a consideration of the requirements of each examining body, and the standard of its examination; and, if it is satisfied, it has the power of enrolling the name of the licensee upon the register, which it is its duty to prepare and publish from time to time.

The Dentist's Education. Before considering in detail the course of study prescribed by the Council and the Examining Bodies recognised by the Council, it will be well to make a few remarks upon the preliminary education which should precede the special study of dental surgery. In preparing for the practice of dentistry it will be seen that some importance attaches to the kind of education which a boy whom his parents wish to educate as a dentist is to receive at school.

Dentistry is to a great extent a handicraft, and its successful practice demands manual skill of a high order. Long before the student begins his special work, much can be done to endow the fingers with suppleness and the mind with mechanical aptitude. Finger-training can hardly be started too early; at school, the special classes which have this object in view—such as carpentry, Sloyd work, and working in metal—should be attended; while out of school hours every encouragement should be given to tastes which turn in the direction of mechanical engineering. The piano and violin, too, provide valuable forms of finger training, and the time spent in learning to play these instruments will, even from this point of view, not be wasted. Again, the relation of a dentist towards his patients being of so personal a character it is of great advantage to the former that he should be possessed of a good education; but when a choice has to be made between literary and scientific studies, the preference should undoubtedly be given to the latter. Such a choice has generally to be made at some stage of school education, and it will then be advisable not to pursue the study of languages and general literature if this involves the sacrifice of time which might be devoted to chemistry and physics.

Preliminary Examination. The General Medical Council holds that the prescribed period of bona fide dental education begins with the registration of the student as a dental student, and, before it will consent to register a student, the latter must produce evidence (*a*) that he is at least 16 years of age; (*b*) that he has actually begun the study of dentistry; and (*c*) that he has passed a recognised preliminary examination in the subjects of general education. [See Schedule of Examinations]

It therefore follows that during a boy's last year or so at school he should be prepared for one or other of the preliminary examinations in the subjects of general education. The Council has decided that the preliminary examination chosen must be a test of proficiency in these subjects:

(1) English grammar, paraphrasing, composition; English history, and geography.

(2) Latin grammar; translation into English from unprescribed Latin books; translation into Latin of a continuous English passage and of short idiomatic English sentences.

(3) Mathematics: arithmetic, algebra (including easy quadratic equations), geometry (including the subject matter of Euclid, Books I., II., and III., and simple deductions).

(4) One of the following subjects:

(*a*) Greek: Grammar, translation into English from unprescribed Greek books, translation into Greek of short idiomatic English sentences; or

(*b*) A modern language: Grammar, translation into English from unprescribed books, translation of a continuous English passage and of short idiomatic English sentences.

The Standard of Proficiency. Full information as to the examinations which are recognised by the Council as constituting a fair test of proficiency in the subjects of general education can be obtained at the offices of the Council, and it is unnecessary to do more than refer to the following as typical examples which will serve to indicate the standard of proficiency demanded:

(*a*) Junior Local Examination of the Universities of Oxford and Cambridge.

(*b*) Matriculation Examination of the Universities of London, Manchester, Liverpool, Leeds, Birmingham, Wales, and Ireland.

(*c*) Preliminary Medical Examination of the College of Preceptors and of the Royal College of Physicians and Surgeons in Ireland.

(*d*) Examination for first-class certificate of the College of Preceptors.

Choice of examination is naturally to be determined in many cases by the age and abilities of the student, and the locality of his

home or school; but it should be said that, where possible, preference should be given to the matriculation examination of some university, since success here is the first step towards obtaining any degree conferred by the University; and this the student may well at some time desire to follow up by taking one or other of the degrees.

Apprenticeship. The preliminary examination having been disposed of, the next step for the student is to apprentice himself to a registered dental practitioner, who undertakes to instruct him in dental mechanics. A word of explanation is here necessary. Reference has been made to that part of the dentist's work which consists of the fitting of artificial teeth to the mouth, to supply the place of those teeth which have been removed. Neglect to preserve the natural teeth, and the consequent recourse to extraction for the relief of pain and unhealthy conditions, result in the frequent need for artificial substitutes; this branch of dentistry is consequently very important, and occupies a large portion of the dentist's time and energy. A great deal of the work can, however, be done in the absence of the patient, if an accurate model or copy of the jaws be first made in plaster of Paris. A dentist, therefore, needs a workshop where the purely mechanical part of the work can be done; and, if he has a sufficient number of patients to occupy his time day by day, it is obviously economical for him to employ workmen to undertake the work which can be done on the model. This work is called dental mechanics, and it is in order that he may learn the principles and practice of this work that the student is apprenticed.

Study of Dental Mechanics. The General Medical Council prescribes that three years shall be spent in the acquisition of this knowledge and skill; and, although the regulations allow that one year should run concurrently with a year of the hospital instruction, which naturally follows the apprenticeship, it is certainly better, unless the abilities of the student are very exceptional, to devote the full three years to the study of dental mechanics. Unless the student lives near the hospitals where his education is being carried on it is, of course, essential that he should complete the three years of his apprenticeship before he joins the hospitals; but even where this is not the case, the importance of a thorough grounding in the work both for its own sake and for the sake of the finger-training which it affords, renders it desirable not to curtail the time specially devoted to learning dental mechanics.

Terms of agreement are consequently drawn up, in accordance with which the pupil or apprentice attends in the work-room during stated hours of the day for a period of two or three years. He is under the supervision of the dentist, whose duty it is to see that he is properly instructed.

SCHEDULE OF EXAMINATIONS FOR DENTISTS

Before entering for these examinations students are required to have passed a Preliminary Examination in Arts, such, for example, as the Matriculation. [For particulars see text.]

Examining Body, Time and Place of Examination.	Subjects of Examination.	Fees and Age Limits.
Royal College of Surgeons, London		
1. Preliminary Science Examination. January, March, July, and October	Chemistry, Physics, Practical Chemistry	£3 3 0
2. First Professional Examination. May and November	Dental Mechanics, Dental Metallurgy	£2 2 0
3. Second Professional Examination. Part I. May and November	General Anatomy, Physiology, Pathology, and Surgery.	£2 2 0
Second Professional Examination. Part II. May and November	Dental Anatomy and Physiology, and Dental Surgery and Pathology	£3 3 0 and £10 10 0 for diploma. 21 years.
Royal College of Surgeons, Dublin.		
1. Primary. February, May, and November	Physics, Chemistry, Metallurgy, Anatomy, Physiology, Histology, Surgery	£10 10 0 17 years.
2. Final. February, May, and November	Dental Mechanics, Dental Surgery	£10 10 0 21 years.
Faculty of Physicians and Surgeons, Glasgow.		
1. First. Division I. March, June, October	Chemistry and Physics	£3 3 0
Division II. March, June, October	Human Anatomy and Physiology	£3 3 0
2. Final	Surgery, Medicine, Dental Anatomy, Physiology, Pathology, Mechanics, and Metallurgy.	£9 9 0 21 years.
Royal College of Surgeons, Edinburgh.		
1. First. April, July, November	Chemistry and Physics, Anatomy and Physiology ..	£5 5 0
2. Second. April, July, November ..	General Surgery, Medicine and Therapeutics, Dental Anatomy, Physiology, Surgery, Pathology, Mechanics	£10 10 0 21 years.
Victoria University, Manchester.		
1. First. June and September	Chemistry and Physics	£2
2. Second. May and November	Dental Mechanics and Metallurgy	£2
3. Third. March and July	General and Dental Anatomy, Physiology, and Histology.	£3
4. Final. March and July	Surgery, Operatic Dentistry, Dental Surgery and Prosthetics.	£3 and £5 5 0 for Diploma 21 years

The work is so essentially practical in nature that little theoretical instruction is given, and it is learnt bit by bit from the mechanic or workman employed by the dentist. The pupil watches the mechanic at work, and carries out the practical instructions which the latter gives him. By constantly carrying out the various processes involved, he gradually acquires the necessary skill and knowledge of the materials and appliances with which he has to deal. To most young men the work is at first far from interesting, involving as it does a large amount of sheer drudgery; and a good deal of the work can only be described as grimy. Its importance, however, cannot be exaggerated, and interest increases with application and the steady progress of familiarity with the varying processes.

The Dental Pupil in the Hospital. Of recent years several of the dental hospitals have inaugurated the practice of receiving pupils in the work-rooms attached to them. The principle is exactly the same, the pupil being in this case apprenticed to one of the registered dental practitioners who attend the hospital as members of the honorary staff; but the system offers certain advantages to the pupil which are well worth considering. The pupil has the advantage of being connected with the hospital from the first, and has consequently the opportunity of becoming acquainted with the hospital system before he enters as a student; he is better able to appreciate the importance of learning his work thoroughly; he is associated with others who are in the same position as himself, and is, therefore, from the first brought under the influence of a healthy rivalry. Further, the methods of working which he is taught are generally more up-to-date than those which prevail in most private workshops. He is able to attend lectures dealing with his subject, which should counteract the natural tendency to become a mere rule-of-thumb workman; his instruction is generally better systematised, and the mechanic from whom he learns his work is usually appointed specially for the purpose of instructing, and is consequently better able to teach him than the average mechanic in a private workshop.

The Private Pupil. On the other hand, a private dentist who conscientiously performs his duty towards his pupil should be able to give perfectly adequate instruction; the private pupil has the advantage of gaining some insight into the conduct of a practice, which is valuable to him later on; he may gain useful experience if he is invited sometimes to assist in the surgery; he is more immediately under the supervision of the dentist to whom he is apprenticed, and it often happens that a dentist is willing to take his apprentice, after he is fully qualified, as his assistant, and subsequently his partner. In many cases questions of economy and convenience will, of course, have to determine the choice between these two alternatives.

As soon as the pupil has entered upon his apprenticeship he should be careful to register himself with the General Medical Council as a Dental Student.

During the period of his apprenticeship, in addition to the work which he has to do in the work-room, it will be well for the pupil to begin to prepare himself for his next examination. This is the preliminary examination conducted by the various examining corporations whose licence in dental surgery is recognised by the General Medical Council, for the purpose of registration as a dental practitioner. The following is a list of the licensing corporations recognised by the Council:

The Royal College of Surgeons of England.

The Royal College of Surgeons in Ireland.

The Faculty of Physicians and Surgeons of Glasgow.

The Royal College of Surgeons, Edinburgh.

Victoria University, Manchester.

The Universities of Dublin, Liverpool, Leeds and Sheffield.

The requirements of the various examining bodies vary both as to the subjects of examination and as to the standard of knowledge demanded. All include the subjects of chemistry and physics; the Corporations of Glasgow, Edinburgh, and Ireland, also require anatomy and physiology, while the Irish College takes the subject of general surgery in addition. At Glasgow and Manchester women are admitted as candidates for the licence.

Preliminary Science Examination. At the offices of the various corporations full information can be obtained concerning the subjects in which the student is examined, and synopses are supplied which indicate sufficiently clearly the range of knowledge over which the examination will extend [see also Schedule]. For the purposes of this article it will be sufficient to discuss from this point onwards the requirements of the Royal College of Surgeons of England, which will serve as an example.

The first examination of the Royal College of Surgeons of England is called the Preliminary Science Examination. The subjects of examination are these: (*a*) Chemistry, (*b*) physics, and (*c*) practical chemistry. The subject of chemistry is held to embrace a knowledge of the general elementary principles of chemistry, and the general character of the chief types of inorganic matter—hydrogen, oxygen, nitrogen, carbon, halogens, sulphur, phosphorus, and the commoner metals and their compounds; general character of the chief types of organic compounds—methane, ethane, ethylene, acetylene, chloroform, alcohol, phenol. Physics includes the elements of general physics, heat, light, sound, and electricity. Practical chemistry includes simple qualitative analysis, volumetric analysis, and preparation of salts. Full synopses can be obtained from the secretary of the Royal College of Surgeons, Victoria Embankment, E.C.

Instruction in these subjects has to be obtained from educational bodies which are recognised by the College as giving instruction of the standard required. A great number of teaching institutions existing in this country are recognised by the College, and, without giving a complete list, the following may be mentioned as typical examples: Municipal Technical Schools

of Manchester, Leicester, Halifax, Hull, Derby; Polytechnic Institutes of Regent Street W., Chelsea, and Battersea; and many public schools.

Course of Study. During his apprenticeship the student will, therefore, be well advised to take a course of instruction in the subjects of the Preliminary Science Examination, if there exists in his locality a teaching institution recognised by the Royal College of Surgeons. If possible, it will, of course, be better to attend the scientific lectures and classes during the evenings, as in this case the theoretical studies will interfere as little as possible with the work which the pupil is doing in the work-room. This is a matter of some importance, and, if it can be arranged that the pupil shall leave his dental work at five o'clock—as is generally the case—he has a long evening before him for his classes and recreation. When he is, in the opinion of his teachers, sufficiently prepared, he will present himself for examination, having obtained from the school a certificate of having attended the lectures and classes to the satisfaction of his teachers. This certificate has to be forwarded, with other requisite forms, when application to be examined is made.

If, after this examination has been successfully passed, sufficient time has still to elapse before the period of apprenticeship comes to an end, the pupil will do well to take up the elementary study of those subjects which are subsequently to occupy his mind so largely.

As an elementary book, the late Professor Huxley's "Elementary Lessons in Physiology," or the smaller, but more up-to-date, "Physiology for Beginners," by Professors Sir Michael Foster and L. E. Shore, may be recommended; while any time spent in familiarising himself with that part of the study of anatomy which is concerned with the bones of the skeleton, will well repay the student when he comes to tackle this subject in earnest at the hospital. In some cases it will be well to start forthwith preparing for the next examination, and with this end in view the student should obtain one of the numerous books on the theory of dental mechanics—such as Richardson's—and at the same time begin the study of "Dental Metallurgy" (E. A. Smith).

As the three years of apprenticeship draw near their close, steps should be taken to enter the pupil as a student at both a general hospital and one of those specially devoted to dental surgery, in order that he may start the prescribed hospital course.

The Student's Hospital Course. Here, again, choice has to be exercised between several institutions. We give a list of the principal educational bodies which are recognised:

London. Royal Dental Hospital and School of Dental Surgery, Leicester Square; National Dental Hospital and College, Great Portland Street; Guy's Hospital Dental School.

Manchester. Victoria Dental Hospital and Victoria University.

Liverpool. Liverpool Dental Hospital and University College.

Birmingham. Dental Hospital and School.

Bristol. University College.

Edinburgh. Incorporated Dental Hospital and School.

Glasgow. Dental Hospital and School.

Dublin. Incorporated Dental Hospital and Dublin University.

Sheffield. University and Dental Hospital.

Leeds. University and Dental Hospital.

Newcastle. University and Dental Hospital.

The factors which must determine the student's choice of hospital are naturally several, and will vary in different cases. Men thoroughly capable of performing the work which their profession entails have received their education at each and all of the hospitals mentioned.

Choice of a Hospital. The larger hospitals, of course, afford the opportunity of somewhat wider and more varied experience, are, generally speaking, more efficiently equipped, and served by lecturers and instructors of higher powers and distinction. But this is compensated for, to some extent, by the more personal relations which subsist between the students and staff of a smaller hospital. It is specially worthy of consideration that there is a tradition attaching to certain centres of education and certain hospitals; and the fact that a dentist has been educated at a dental hospital which has a high reputation in the profession, and bears a name with which the general public is familiar, will naturally give him a better standing than he would have if the case were otherwise. This point tells especially in favour of the group of London hospitals.

The student has not only to attend classes and perform operations at a special hospital devoted to dentistry, but also to take a prescribed course of instruction at a general hospital; and it is best to enter as a student at both hospitals simultaneously.

The Student in the Hospital. Guy's Hospital, for instance, embracing as it does both a general and dental department, offers special facilities; while students at the Royal Dental Hospital of London and the National Dental Hospital respectively, will find Charing Cross and Middlesex Hospitals most convenient for their purpose. The Royal College of Surgeons directs that at least two years should be spent in attendance at a recognised dental hospital, and the same period at one of the general hospitals; but it is permissible and quite usual to take the two courses concurrently, the whole of the hospital course being thus completed in two years.

The subjects in which instruction is to be received are determined and clearly stated by the College, and the student when he presents himself for examination has to produce certificates to show that he has attended the necessary classes to the satisfaction of his teachers.

The two years spent in this work should be very busy ones, for the time prescribed is certainly not too long for the work which has to be performed. The student should realise to the full that his future career depends largely upon the use which he makes of the opportunities which the hospital course affords, bearing in

mind not only the examinations which loom large in the immediate future, but still more the surer test of private practice during the years to come.

During the first few months of his hospital career, in addition to the lectures which he has to attend, the student is instructed how to perform the various operations involved in the practice of dental surgery. At first he learns to operate upon models, blocks of ivory, or teeth which have been extracted; and when, in the opinion of his teachers, he has acquired sufficient skill, he is drafted into the operating-room, and has to attend to actual patients under the direct supervision and with the help of specially appointed instructors and demonstrators, who are selected from the ranks of qualified dentists.

The Two Professional Examinations. The first examination which has to be faced after the hospital course has been begun is called the First Professional Examination. This should be taken after the student has been attending the hospital for six months, and the subjects in which his knowledge is tested are dental mechanics and metallurgy. The examination is conducted partly by means of written papers, partly by means of practical work, the student being required to carry out some piece of mechanical work which he has learned to do during his apprenticeship. After eighteen months' further study and practice at the hospital, he should present himself for the final test.

The second professional examination is divided into two parts. Part I. embraces the subjects of general anatomy and physiology, general pathology and surgery; Part II. deals with dental anatomy and physiology, dental pathology and surgery, and practical dental surgery. The student has attended some of the classes at a general hospital which are primarily intended for students who wish to take a medical qualification, and his examination deals in part with the subjects of medical and surgical education. The examination consists of questions to be answered on paper, questions asked vivâ voce by the examiners, and actual operations in dental surgery required to be performed.

Qualifying for L.D.S. The College of Surgeons has recently given permission to the effect that the student may elect to be examined separately in the two subjects on condition that Part I. be taken first, and this course presents certain obvious advantages. Part II. may not be taken until six months have elapsed since the student passed the First Professional Examination, but may be taken at any time after this.

The examinations having been successfully passed, the student is entitled to receive the diploma or licence of the College of Surgeons, and should proceed to the offices of the General Medical Council in order to be enrolled on the register as a dental practitioner. His title is now Licentiate of Dental Surgery, for which the initials L.D.S. are an abbreviation.

With this qualification the dentist is entitled to enter upon private practice, and his hospital education may be considered to be at an end.

He may, however, if he choose, render himself more efficient in one or both of two ways. Attached to the dental hospitals are a number of young qualified practitioners who act as house surgeons. A number of such posts are held at a large hospital, candidates being selected by the governing body of the hospital, and the student will be well advised to undertake these duties.

The Higher Degrees. The other method by which the dentist can increase his efficiency is by pursuing his studies still further, and acquiring additional qualifications or degrees. Probably the wisest course is to take one of the medical or surgical qualifications, and of these the most serviceable is perhaps the diploma granted by the combined board of the Royal College of Physicians of London and the Royal College of Surgeons of England (L.R.C.P., M.R.C.S.). The advantages of this additional study and diploma are considerable. It has been shown that the curricula of education of the medical and dental student at a general hospital are identical up to a certain point, so that within these limits the full medical education only amounts to a more intimate knowledge of the different subjects, which adds greatly to their interest; while the wider range and more scientific character of the medical education tells beneficially upon the quality of the knowledge which the dentist has to acquire and use in his daily practice. The additional qualification gives the dentist a better standing in his profession, and tells in his favour if he wishes to obtain appointments on the staff of a hospital; and it also allows him a definite choice between two professions. It is, at any rate, a wise course to enter for the medical examinations which are held in those subjects which are learnt by both the medical and dental student; and the further course, which involves two and a half or three years' additional study, may then be taken.

An alternative plan to this is to visit the United States of America after taking the English dental diploma, there study at one or other of the dental hospitals, where valuable experience can be gained, and acquire the degree of Doctor of Dental Surgery. The dental degrees granted by the Universities of Birmingham, Manchester, Dublin and others are also recognised as attesting a riper knowledge and enhanced skill, while the special study directed towards the acquisition of a university degree in arts or science should mean increased efficiency.

The Dentist's Balance-sheet. It is of importance, from the parents' point of view, that some indication should be given of the expenses involved in the training of a student for the practice of dentistry, the cost of the materials and furnishing necessary in setting up in practice, and the amount of remuneration which he may be likely to earn. Such estimates can of necessity be only approximate at the best. Accommodation is naturally more expensive in one town than another, and the expense of

London lodgings must be taken into consideration. The cost of board and lodging is, for instance, so uncertain an amount, that in the table which follows it has been thought better to give no estimate at all.

It should be remembered also, that success at the first attempt in the several examinations is by no means universal, and failure generally involves the payment of additional fees to the hospitals and examining bodies, and an additional course of study for three or six months. It is, in some cases—although not generally—wise to undergo a course of special instruction from a tutor who coaches or prepares students for the examinations, and this may involve an additional fee of ten guineas, which has to be added.

Initial Expenses. We will consider first the cost of the licence in dental surgery of the Royal College of Surgeons. The fees for registration as a student and, after the examinations have been passed, as a dental practitioner, amount to £5. The cost of apprenticeship varies according to the locality and the professional status of the dental practitioner to whom the pupil is apprenticed, but the average charge may be taken as 100 guineas. For the special course of study and practice at a dental hospital extending over two years, 50 guineas is, approximately, the fee generally charged in the metropolis, while at the provincial hospitals £25 is the more usual fee. The fee charged for instruction in the subjects required, and the prescribed attendance at a general hospital, varies from 50 to 60 guineas.

The student on joining the hospital is required to provide himself with a set of tools and instruments, the cost of which, together with the cost of replacing those which are lost or worn out, and keeping them in good repair, cannot be estimated at less than £30.

Setting up in Practice. The cost of establishment in practice cannot be estimated with any approach to accuracy. It may be taken that the furnishing of a room as a dental surgery, and its equipment with proper appliances, will cost £100 ; while £25 would have to be spent upon the work-room, and another room would require furnishing to serve as a waiting-room for patients. If, on the other hand, the young practitioner elects to work into the established practice of another dentist, beginning as his assistant, he will probably require a considerable sum of money if he is to purchase a share in the business.

Apart, therefore, from the cost of living, the necessary expenditure may be indicated in the following table :

For L.D.S. Diploma

	£	s.	d.
Registration	5	0	0
Apprenticeship	105	0	0
Hospital education	120	0	0
Examinations	21	0	0
Instruments	30	0	0
Books	5	0	0
	£286	0	0

If it is decided to take in addition the diploma of the Conjoint Board of the College of Physicians and Surgeons—as is strongly recommended—we have to take also into account, in addition to the cost of living for an additional three years, the following items :

	£	s.	d.
Registration	5	0	0
Hospital education	63	0	0
Examinations	38	17	0
Instruments and books	10	0	0
	£116	17	0

Some indication having been given of the outlay necessary to equip a dentist for the proper performance of his work, it remains to refer to the other side of the balance-sheet, and to point out in what way the expenses can be set off by remuneration. In the first place, therefore, it can be stated that although the training and equipment of a dentist is both long and expensive, and the examinations entail much study and application, the profession is not over-crowded, and a capable dentist is still in request in most towns.

Profits. The profits of a busy dental practice, of course, may vary greatly in accordance with the capacity of the dentist and the wealth of his patients, seeing that the fees which he is able to obtain will be very different in a fashionable quarter of London or a provincial town with wealthy residents settled round it, as compared with a working-class suburb or a small manufacturing town. But it may fairly be said that a dentist in full practice who did not make more than £500 clear profit a year would not be considered as very successful financially ; while a young qualified man, acting as assistant to another dentist, would expect to be paid at the rate of four guineas a week in a good provincial practice, and five guineas a week in London.

As a set-off against expenses of education, there are opportunities for the brilliant student to earn valuable scholarships and prizes, which at several hospitals amount in all to more than the actual cost of education. Hospital appointments, again, such as the post of house surgeon or demonstrator, generally carry with them an honorarium, amounting to about £40 a year in the first case, and £80 in the second.

What the Dental Mechanic Earns. Concerning the dental mechanic, a word should be added to the effect that whereas his education actually costs him no more than the cost of living, his wages during his apprenticeship are very small, starting probably with 5s. a week, and slowly rising. When he has completed this period of five or seven years, as the case may be, he may obtain his first situation as mechanic, or "improver," as he is called, when his wages would start at 30s. a week, and gradually rise ; so that a really good mechanic of several years' experience would expect to earn £3 in the provinces and £4 in London. Some obtain wages more than this, while others, by fitting a workshop for themselves, and carrying out work for dentists, earn considerably more in one of the busy centres of population.

Continued

Group 9
DRESS
40
MILLINERY
continued from page 5621

MILLINERY FOR MOURNING

Widow's Bonnet and Veil. Crape Hats. The Making of Veils of all Kinds. Caps. Fancy Muffs and Fur Toques

By ANTOINETTE MEELBOOM

CRAPE, being a harsh and wiry material, requires great care in its manipulation. The bright side with the marks raised is the *right* side, the diagonal line running from left to right from selvedge.

For trimmings it is always cut on the cross [**171**], across the grain, as all diagonal woven materials are cut. The lines will run *strcight* across, from cut edge to cut edge, in a crossway length of crape. Pin before cutting to keep it in place.

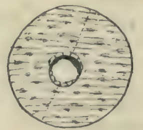
To make a hem in crape turn in $\frac{3}{4}$ in. and then turn in the same width again, so that the hem is quite double. Tack as for crape and slip-stitch with crape cotton (dull black), keeping the hem perfectly straight and round looking.

Crape Hats and Bonnets. Make the shape of a crape hat of double black stiff unglazed net. Cover the shape first with domette, dull sarcenet, silk, chiffon, aerophane, or old crape.

Cover as for velvet, being careful that the grain runs in the same direction in both upper and under covering, if an interlining of crape has been used. The grain of the crape should go *straight* across the front of the brim [**169**]. For hard wear a foundation made of spatrie is preferable.

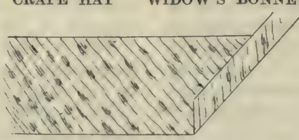
Widows' bonnets [**170**] are generally close fitting of the Marie Stuart or Dutch shape type, with or without a coronet.

Make a wire shape, cover it with tulle or dull chiffon, and mull the edge. Headline it and sew in a narrow fold of velvet to assist in the fitting. Widows' bonnets are mostly trimmed with folds, pipings, an Alsatian bow, or folded knots of crape, dull corded silk, lisse or chiffon.

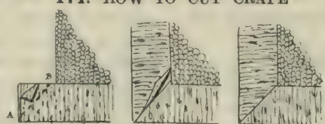


169. CRAPE HAT

170. WIDOW'S BONNET



171. HOW TO CUT CRAPE



172 173 174
CRAPE VEIL

To make the piping, cut strips of $1\frac{1}{2}$ in. wide on the cross. Tack in a black piping cord and stitch on each row just below the cord, keeping the cord slightly stretched. Interlining the folds with domette, piping cord or wadding gives them a soft, rounded appearance. The coronet is usually made of folds. Make the crown gathered, draped, or with a few tiny tucks in which fine wire can be run, pulled up and fitted like a fan round the crown. Dull black bengaline silk is often used for crowns and trimmings.

Two yards of dull black ribbon will make the strings, and a white lisse front should be sewn in to finish the bonnet.

Widows' Veils. Veils take one yard of large meshed Brussels net, lisse or grenadine 36 in. wide, and 45 in. long.

Divide $\frac{3}{4}$ yard of crape on the cross into three strips. Turn in and tack a $\frac{1}{4}$-in. turning along each edge. Place the two long sides and one short side of the net between these edges and tack about $\frac{3}{4}$ in, in from the edge. Slip-stitch the crape to net on each side, being very careful not to stretch it.

Mitre the corners. It should be done in this way. Let the crape project along the lower edge for $2\frac{1}{2}$ in. at each side. Cut off the corners A to B [**172**]. Do the same with the other corners, letting the lower edge corner come *over* the others [**173**]. Slip-stitch the turnings on each side [**174**].

A "waterfall" veil has the hem the same width all round.

Straight veils are 1 yard long, with a 9-in. deep hem at the bottom, a 2-in. hem at the sides, the length of which is cut off first to get the right side of the crape uppermost.

Hem the top edge of net. Hold it in the right hand at right hand top corner, and fold backwards and forwards about ten times till the crape border goes up at the length of the veil to the top. Then set it on to the bonnet.

Confirmation Veils. Confirmation veils are made from 18 in. to 27 in. long in the same way, except that the Brussels net is cut wide enough to allow a 2-in. hem all round.

Turn it in 2 in. all round. Turn this over again for 2 in., so that the hem is *quite double.*

Use the whole width of the tulle and mitre the corners. Use a running stitch about $\frac{1}{2}$ in. long on right side and $\frac{1}{8}$ in. on the underside, and run with floss silk or filoselle.

Bridal Veils. For bridal veils the corners may be embroidered. They are made in the same way as confirmation veils. For these a special make of net can be bought.

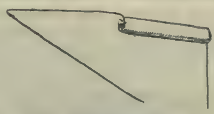
Silk. Silk for trimming is always cut on the cross. Join the widths, and make a hem $\frac{1}{4}$ in. wide when finished. Turn the hem to the right side of the silk [**175**]. When coming to the join, snip the selvedges and turn them to the upper side in order to be invisible when the hem is turned to the right side. Slip-stitch it with a very fine needle, and sewing silk to match in colour. Let the stitches show as little as possible, and avoid

crushing the hem. A fine wire is sometimes inserted in the hem.

Another method, which is much neater and need have no stitches showing on either side, is a French hem at either edge [179]. The method is this. Leave 1 in. plain; make a tuck ¼ in. wide when finished; turn in the raw edge, and slip-stitch it exactly on the line of running.

For shapes plainly covered with silk it is best to have an interlining of some soft material, as all marks, wires, etc., show through.

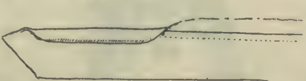
Caps. The foundation of all caps is of double stiff net [177], and should be wired along the top edge with finest wire or two strands cut from ribbon wire. Bind it with sarcenet ribbon about ½ in. wide.



175. HEMMING SILK

Bind the outer edge with ribbon or velvet on the cross to match the trimmings, or the velvet may be eased on as for a rucked edge. One or two straps may have to be sewn to each side to keep the cap in shape, and for help in sewing on the trimming. A cap is entirely a matter of individual taste. It can be made of ⅝ yd. of lace, or as much as 5 yd. can be used. An average quantity is 2 yd. and 1½ yd. of ribbon 1½ in. wide or about 6 yd. of baby ribbon.

176 177
CAP FOUNDATIONS



179. FRENCH-HEMMING SILK

In trimming remember that the outline of the cap must be hidden; therefore let the lace droop over the edge, and see that the trimming is not too long at the back.

The trimmings are tie-stitched wherever possible. Larger cap shapes are cut out with ¼ in. turnings. Fold the turning over the wire (two strands of ribbon wire may be used), and wire-stitch it all round to shape. Make the join of the wire come in the centre of the inner edge of the cap, and let the wire overlap for 2 in.

Cap for Elderly Lady. The foundation of caps for elderly ladies is made in stiff net, covered with lisse, and wired with fine soft wire, slightly drawn in centre of front, and bound with ribbon to match the cap trimming [176].

Make a box pleating of stiff net across front to stand up and support the trimming; cover it with lisse to soften and disguise it.

Make a bag of black net at the back, confined by an elastic, which is fixed to foundation at ears. Depth of crown, 13 in. to 15 in.; width at back, 15 in., drawn up to about 7 in. by the elastic [176].

Wave the lace round edge 1½ in. below shape to rest on the hair; make ribbon loops between each fold of the lace at the sides. Raise the trimming in the centre-front, and finish with a rosette of the ribbon or any other trimming.

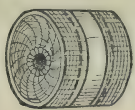
Make lace lappets [166–168] 18 in. long when finished; sew them on from each ear of foundation with ribbon.

For the back, join the lace as for lappets. Let the ends fall over the top piece of crown in waves, and let it meet the trimming of the front. Use ribbon bows to neaten the lappets and fix it on to the net crown.

Muffs. The foundation of fancy muffs must be large or small according to the prevailing style. Cut two or three layers of wadding, a little wider than the muff is to be, and allow 4 in. or 5 in. to overlap; 9½ in. by 15½ in., not allowing turnings, is an average size [178].

Inflate the wadding before the fire or over a gas-stove till it separates and looks light, and join it in a round. Use for lining, silk, satin or merveilleuse; cut this the same outside length as the muff and half as wide again for width. Join in a round.

Run two casings [178] at each side, just beyond the wadding. If a frill besides the casing for elastic is required, more turning must be allowed.



178. MUFF

Insert the elastic, running it in the casing, through the join, and secure it in a round large enough to pass the hand through. Draw the lining in the muff, with the centre of muff to centre of lining. The ends of the lining beyond the casings for elastics are turned back over the wadding; push it well to shape at the sides, and tack the silk lightly to the wadding.

If needed, cut deep frills of about 7 in. by 40 in., on the cross, lined with leno and silk. Of 42-in. cloth, ⅝ yard will be required; of 20 in. velvet about 1 yard, on the cross, will make a fair-sized muff.

Fur Toques. A wire shape covered with leno or fine book muslin makes a good foundation for a fur toque. Mull the edge of the toque and cover the under-brim with velvet or cloth.

In sewing fur, use a short needle and strong cotton; sew it through the skin from the back, holding the fur well down. With each stitch only draw through to the right side sufficient cotton to be able to turn the needle back again. When the cotton is being drawn it will be close down on the skin of the fur. This prevents drawing some of the fur through, and probably causing the cotton to break.

Fur is not generally used for the under-brim, as it would make the toque too heavy to be worn comfortably.

Often pieces of fur have to be joined or worn pieces cut away and better ones patched in. The best parts of a fur necklet or muff make a good border to a toque of the turban variety. When lined with a layer of wadding, and faced with satin, the fur would make a band of trimming for a hat.

Beaver, chinchilla, sable, ermine, and grebe are favourite furs used for millinery purposes. White and pink camellias or carnations, shaded velvet chrysanthemums, and Neapolitan violets, look particularly well on fur, while a rich purple velvet, turquoise blue velvet, or a little real lace are favourite trimmings.

Continued

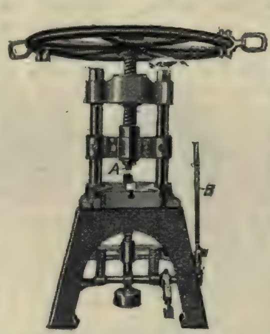
POTTERY
continued from page 5607

ARCHITECTURAL POTTERY

The Making and Laying of Tessellated Pavements and Mosaics. Salt Glaze Ware. Drainpipes. Architectural Faïence and Terra-Cotta

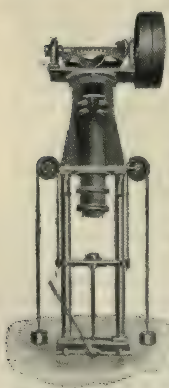
By MARK SOLON

THE branch of the trade dealing with tessellated pavements and mosaics varies more particularly in the manipulation of the body than those already considered. The bulk of the tiles for tessellated pavements, instead of being made from plastic clay, are pressed from a semi-plastic dust. The body, having been prepared in the usual way, is taken from the filter presses and thoroughly dried. It is then damped slightly, broken into small pieces, and passed through a *disintegrator* [37]. This is a small machine consisting of a solid metal drum to which are attached four or six metal arms. The drum is made to revolve at the rate of about 3,000 revolutions a minute, causing the arms to strike the clay which is fed into the machine against a series of small *grids*. These grids are supported inside a circular metal casing, which collects the dust and allows it to fall through an opening at the bottom of the machine. It is afterwards sifted, and kept for a day or so in order to allow as much air as possible to escape from it.



35. SCREW PRESS FOR SHAPING TILES

Colours Produced from Natural Marls. Various colours are produced from natural marls, either alone or stained with metallic oxides—the red from red marl alone, the buff from buff marl, black from inferior red marl stained with manganese and ironstone, chocolate from red marl stained with manganese, drab from buff marl with a small quantity of manganese, salmon from buff and red marl. The white tiles are made from a mixture of ball clay, china clay, flint and stone, with sufficient of the latter to cause them to vitrifly slightly during firing. The brighter colours, such as blues, greens, sage, etc., are obtained by staining the white body with mixtures of cobalt and chrome. The shape of the tile is given by a steel die or box, the top and bottom of which are movable in order to press and eject the tile. The die is fitted under a screw press of special design [35], the top cover of the die being attached to the screw A, the bottom die to the lever B. The box is filled with clay-dust, and pressed by revolving the wheel, thus lowering the top die. After being properly pressed, the bottom die is raised with the lever B and the tile delivered.

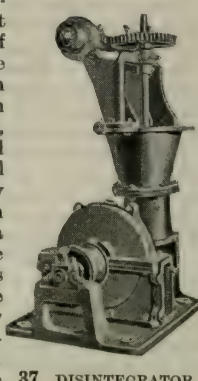


36. PIPE-MAKING PRESS

Each tile must be submitted to at least two or three distinct pressings in order to liberate the air from the dust. The effect of pressing the tile in an enclosed box is to compress the dust and the air simultaneously. As the pressure comes entirely from above, the top layer of dust in the box is the first to be compressed, and so prevents the air from escaping through it. It is, consequently, confined in the body of the tile, which it splits up into thin layers. By releasing the pressure between each successive application, the compressed air is allowed to escape and a solid tile eventually formed.

Encaustic Tiles. The ornamental tiles introduced into pavements are known as *encaustic* or *inlaid tiles*, the figure or ornament being inlaid in various coloured clays to the depth of about $\frac{1}{16}$ in. in the face of a tile. They are produced either by the plastic or by dust process, of which the former is the more costly but greatly superior method.

The plastic process consists of pressing from a plaster mould clay tiles in which the ornament is sunk in the face. The tilemaker proceeds to fill in the depressions which form the ornament with various coloured slips, pouring them on the face of the tile from suitable small cans. The tile is allowed to dry until the slips have become fairly hard, when the excess is carefully scraped from the face of the tile and the pattern discovered. There are many different methods of producing encaustic tiles on the dust process, the simplest of which is the following: The ornament is described in thin bands of brass, which are soldered together. This, when placed upon a metal plate, forms a series of small compartments bound by the brass ribbon. Each compartment represents a separate colour in the design. The workman fills in each colour until the metal plate is entirely covered. The bands forming the ornament are then gently removed from the



37. DISINTEGRATOR

plate, which is put at the bottom of an ordinary die. The die is filled with the dust which is to form the back of the tile. Pressure is applied in the usual way, and when the tile is taken from the press the pattern appears upon the face. The tiles are then gently dried for a few days and fired in the biscuit oven in the usual way.

Mosaic Patterns. When more intricate patterns are required, pavements are made of a number of small tiles or cubes which are cut and fitted together and known as mosaic. The small strips or cubes are prepared from dust in the manner just described, of different coloured bodies, and fired in a biscuit oven. They are arranged in various patterns in the following manner: The ornament required is drawn on strong paper, the reverse way to which it will appear when finished, each colour being outlined separately. The cubes of different colour are then stuck with glue, face downwards, on the paper, being cut with a chisel where necessary to follow the shape of the ornament. The ground of the floor is formed either by arranging the cubes in a fan formation, or by placing together pieces of irregular shape. Having covered the paper on which the ornament has been drawn, and laid in the background with one of these two formations, the sheets so prepared are sent to the building where they are intended to be laid. This space to be covered with mosaic is first floated with liquid cement, upon which are laid the sheets of paper—the paper upwards. The water from the cement rises through the spaces between the cubes, dissolves the glue, and loosens the paper. This is gently removed, leaving the cubes properly arranged in the cement. The surface of the floor is then well beaten with flat pieces of wood, so that the cubes are driven into the cement, which fills up all the joints. The floor is then allowed to remain untouched until the cement is set.

38. MOULD-MAKER COMPLETING TOP OF MOULD
The dark object is the model, partly buried in the slips

Salt Glaze. Glazing by the introduction of salt into the furnace is a method used principally in the manufacture of cheaper forms of pottery, such as drainpipes, ginger-beer and ink bottles, glaze bricks, etc. The body of drainpipes is of natural marl either alone or mixed with a suitable amount of grog or previously fired material. The mixture is so adjusted that the pipe when fired is sufficiently dense to withstand the pressure to which it is submitted when buried in the earth.

On coming from the pit, the marl is passed through a roller mill, heavy iron rollers crushing it through perforated grids. It is then conveyed to the *riddles*, where the larger pieces are abstracted and returned to the mill. The proper proportion of grog is mechanically produced in a mixer, whence the material goes to the pug mill. From this machine it is delivered in plastic slabs, which are conveyed to the pipe-making press [36]. This machine consists of a vertical cylinder, through the centre of which revolves a spiral blade. The clay on being fed into the machine is forced by the blade through an opening or die at the base of the cylinder. The die forms a circular slot of diameter and width to correspond with the section of the pipe required. Below the slot is a metal mould of the socket head of the pipe, the part giving the inner shape to the socket being carried on a movable table which descends as the pipe is expelled from the machine. After the necessary length of straight piping has been pressed, it is cut off and placed upon a *fetling machine*, when the rough edges are trimmed and the surface of the pipe smoothed over. It is afterwards finally finished upon a lathe, the ends of the pipe inside and out being scratched and serrated, to give a better grip to the joint. The pipes are then placed in the drying chamber, and afterwards taken to the oven for firing and glazing.

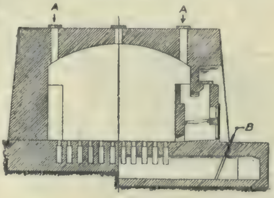
Firing and Glazing Pipes. The pipes are fired and glazed in circular or square down-draught ovens [39]. They are placed one upon another, the small ones inside the larger, care being taken, however, that the whole surface of each pipe is exposed, and can easily be attacked by the gases which are produced at the end of the firing by the introduction of the salt. The action of the salt upon the pipe is principally the formation of silicate of soda, which, being a glass, vitrifies the surface of the pipe. It is introduced into the kiln when the highest heat necessary for the firing of the clay has been attained. The salt is volatilised by the heat, and decomposes on coming into contact with the silica present in the body of the pipe. The richness of the glaze depends to a great extent upon the amount of silica in the clay. Bodies containing a great quantity of alumina do not glaze well.

The salt is dropped into the kiln through holes in the dome [39A], which are so arranged that it does not fall directly on the ware. A large amount of heat is absorbed in the volatilisation and decomposition of the salt, which causes a considerable drop in the temperature of the oven. For this reason the full quantity is not introduced at once, but in two or three operations, at intervals of 20 or 30 minutes. To prevent the vapours from escaping too rapidly from the kiln, the damper, B, is lowered during the introduction of the salt, partially closing the flue and reducing the draught.

Architectural Faïence and Terra-cotta. Architectural pottery and glazed terra-cotta have become more extensively used

for the internal and external decoration of buildings during the last few years.

The *unglazed terra-cotta* is generally of a red, buff, or grey tint, and is made from the natural marls, which contain various quantities of iron oxide, the staining property of the iron being more or less developed by the atmosphere produced during firing. *Glazed terra-cotta* is, as a rule, made from buff marl, mixed with a certain amount of ground-fired material or grog, which is introduced to prevent excessive contraction during firing and drying. The marl is first of all reduced to a slip and prepared as clay, and afterwards pugged, or mixed with the fired material, or, in the case of certain extremely pure marls, merely ground together with the grog and a requisite amount of water.



39. DOWN-DRAUGHT OVEN FOR GLAZING PIPES

Manufacture of Terra-cotta. The manufacture of architectural terra-cotta begins with the preparation of complete plans and elevations, in which the entire scheme of decoration is set out on paper. Every block of terra-cotta which enters into the arrangement is clearly defined and numbered, and a full-sized working drawing made of every different piece. From these drawings models are produced in clay and plaster in the following manner.

Should the piece be perfectly plain—namely, of flat surface and symmetrical shape—the model is built up with plaster in semi-liquid state, and shaped by means of zinc profiles. Ornamental blocks are, of course, either modelled entirely in clay, or the ornament is applied to a plaster form made in the manner just described. After the models are prepared, plaster moulds are cast from them in various sections. These sections, or *slips*, are bound together by an outer frame of plaster [38]. The slips are so arranged that after the piece has been pressed and the outer frame removed they can easily be taken from the clay without disturbing it. The moulds are lined with clay, about 1 in. in thickness, and bridges or supports are built up inside the larger hollow pieces to prevent their collapsing or going out of shape during drying and firing. The surface of the piece on coming from the mould is polished with small steel knives. In some cases, where only one block of terra-cotta of certain shape and size is required in the scheme, and this happens to be elaborate in character, the piece is modelled by hand in the clay, and this actual model fired. If the piece is larger than can be easily handled in manufacture, it is cut into sections, which, when fired, fit together accurately.

The Kiln. After the pieces have been thoroughly dried, they are sent to the kiln. In the case of glazed terra-cotta, muffled kilns are used, the clay blocks being built up one upon another. The kilns are specially constructed, and have an inner chamber, which entirely protects the clay from the flame. The form of muffled oven generally adopted [40] is down-draught in principle. The flame rising from the mouths round the outside circumference of the chamber is collected in the central chimney, the base of which leads into a duct or flue connected with the chimney. Unglazed terra-cotta is generally fired in open kilns, the clay not being protected from the flame. In this way the atmospheres produced during firing act directly on the clay. The pieces are placed upon fireclay shelves, the distance between each being regulated by stout drops to suit the various pieces. After biscuit firing, the pieces are dipped or pencilled with coloured glazes and refired in ordinary kilns. Should the pieces during the firing or glazing become twisted, and so be difficult to build upon one another, or not fit accurately together, they are ground and made true before being fixed. For this purpose the piece is placed upon a revolving iron disc, upon which is continually poured a stream of wet sand.

40. MUFFLED OVEN FOR GLAZED TERRA-COTTA

We are indebted to Messrs. W. Boulton, of Burslem, for many of the representations of machinery, and to Messrs. Doulton & Co., Ltd., for many of the photographs of operations illustrating these articles.

We append a list of technical works on pottery manufacture and decoration.

"A Treatise on the Ceramic Industries." By Emile Bourry. (Scott, Greenwood. 21s.)

"English Pottery and Porcelain." By the Rev. E. A. Downman. (Upcott Gill. 3s. 6d.)

"Notes on the Manufacture of Earthenware." By E. A. Sandeman. (Virtue. 7s. 6d.)

"Architectural Pottery." By L. Lefèvre. (Scott, Greenwood. 15s.)

"Manufacture of Glazed Bricks." By H. Ansell. ("British Clayworker." 7s. 6d.)

"How to Analyse Clay." By Holden M. Ashby. (Scott, Greenwood. 2s. 6d.)

"Ceramic Technology." By C. F. Binns. (Scott, Greenwood. 12s. 6d.)

"Text-Books on Ceramic Calculations." By W. Jackson. (Longman. 3s. 6d.)

"Painting on Glass. Porcelain and Enamel Painting." By Felix Herrmann. (Scott, Greenwood. 10s. 6d.)

"Colouring and Decoration of Ceramic Ware." By Alex. Bronquiart. (Scott, Greenwood.)

"China Painting." By F. Lewis. (Cassell. 5s.)

"Manual for China Painters." By Mrs. di R. Monachesi. (Gay & Bird. 5s.)

Technical Instruction. Classes for the study of theoretical and practical pottery manufacture are held at the Technical Institutes, Tunstall, Burslem, Stoke-on-Trent, and Longton, in Staffordshire, under the superintendence of Dr. J. W. Mellor, D.Sc.

EARTHENWARE *concluded; followed by* CARVING

MORDANTS & OTHER CHEMICALS

Continued from page 5640

The Dyer's Large Store of Drugs. Khaki, Prussian Blue, and Other Metallic Colours. Dyeing-vats and Plant

By HERBERT ROBSON

THE dyer uses a large number of drugs in preparing his material for dyeing—such as mordants as fixing agents and assistants for the mordants, as levelling agents, and as solvents for dyestuffs, etc. The method of preparation and minute description of these substances belong to the domain of general chemistry, and very voluminous works are devoted to the subject; in this course we must consider them purely from the point of view of the dyer.

The French dyers used the term *mordant* (biting) because they thought that the mordants simply prepared the way for dyeing by biting into the fibre and opening the pores. It has long been known that they act by forming a coloured *lake* closely combined with the fibre, either by fixing the dyestuff or by actually forming an essential element in the colour. The mordant must not affect the properties of the fibre and must penetrate it thoroughly, otherwise if it is only superficially attached the colour will not be fast to rubbing.

Aluminium Salts. Aluminium mordants are used on all the fibres and are now, as a rule, prepared from the sulphate known as "cake alum" or "patent alum." *Alum* is the double sulphate of aluminium and potassium or ammonium. Dyers prefer commercial alum to the sulphate, but they are both used as mild acids in dyeing acid colours on wool and as mordants on cotton, but not to a large extent, as very little alumina is fixed on the fibre.

Red liquor is the name given to the acetates and sulphate acetates of aluminium because they are used as mordants in alizarine red dyeing. On wool and on silk the sulphate is the principal aluminium mordant. The other aluminium mordants are principally used in textile printing.

Iron Salts. A large number of ferrous and ferric salts are used by the dyer.

Ferrous sulphate, usually termed *copperas* or *green vitriol*, is employed in the manner described under the head of Natural Colouring Matters, and for darkening the colours obtained with some of the basic coal tar colours.

Pyrolignite of iron or *black liquor* is ferrous acetate containing a little ferric acetate and is used principally by the cotton printer and in black dyeing silk. *Ferric sulphate*, very misleadingly termed *nitrate of iron*, is used very largely in black silk dyeing and for cotton. The real *ferric nitrate* finds a limited use for buff shades on cotton. Copperas is the only iron salt used for wool and also for jute. Blacks are got on this latter fibre by dyeing with logwood and after treating with copperas.

Chromium Mordants. *Bichromate of potash* or *sodium*, often simply called "bichrome," is an everyday mordant for wool. Sulphuric acid is usually added to the dye-bath, and other assistants, notably lactic and formic acids, have been recommended. A very small proportion of bichromate has great mordanting power; in fact, the danger lies in "over-chroming" the wool. *Chromium fluoride* is also largely used, generally with oxalic acid as an assistant. On silk *basic chromium chloride* is used fixed with silicate of soda. The cotton dyer does not use chromium mordants very largely.

Khaki, in really fast shades, is produced with metallic oxides. The word itself means "earthy," and khaki, it is said, has been a military colour from the days of Alexander the Great. Our soldiers in India, in cases of sudden outbreak on the frontier, dyed their white cotton twills in fresh cow dung. The Germans, during the recent war, took with them to China tins containing a mixture of a decoction of chicory and chlorophyll (the colouring matter of grass) with the same object. The Boer war brought khaki very much to the front, and a long range of drab shades produced with natural and artificial dyes are now described under the name. The military authorities are very exacting as to the properties of fastness of the dye when used for uniforms, and fast shades varying from a khaki yellow to a greyish red are obtained with mixtures in various proportions of ferric sulphate, chrome-alum and pyrolignite of iron.

Tin Mordants. The stannic salts are much used for the vegetable fibres, especially with the natural dyestuffs. The wool dyer principally uses *stannous chloride* under the name of *tin salts* or *tin crystals*. *Tin spirit*—that is to say, tin dissolved in acids—is hardly used now. *Stannous nitrate* is employed in dyeing cochineal red on wool.

Copper Mordants. The copper salts are used principally as oxidising agents, but *copper sulphate*, known as "blue stone" or "blue vitriol," is employed to some extent as a mordant in wool dyeing, and cotton dyed with some of the direct cotton colours is after treated with copper sulphate to make the shade better able to resist washing.

Lead Mordants. *Acetate of lead*, known as "sugar of lead," and *nitrate of lead* are used by the cotton dyer in producing the once favourite colours known as "chrome orange" and "chrome yellow." The cotton is mordanted with the salt and passed through milk of lime and then through a bath of bichromate of potash.

A large number of the other metals have been used as mordants experimentally, and some of them have found a use, but principally in textile printing.

The Tannins. A large number of vegetable substances contain tannic acid or an organic acid resembling it in chemical constitution and properties. They are capable of converting hide into leather, and their astringent properties make them useful in medicine as styptics. They are used also in the production of inks and in the manufacture of a class of dyestuffs. Some of them, notably cutch and gambier, contain colouring matter sufficient for use as a dye, and are actually natural combinations of mordant and colouring matter.

The principal value of the tannins to the dyer lies in the fact that, whereas vegetable fibre has little affinity for dyestuffs, it greedily absorbs tannic acid, which is capable of forming insoluble

compounds in the fibre in combination with the basic dyestuffs. In silk dyeing the tannins are principally employed as weighting material and as both dye and weighting material for black silk. In wool dyeing they find a very limited use. The fibre has little affinity for tannin and the small quantity that it absorbs is a resistant to some dyestuffs. Before the days of the artificial dyes many of the tannins were used for the sake of the colouring matter they contain. Tanner's bark, gallnuts, chestnut husks and sumach were all employed as actual dyestuffs in English dye-houses, and country people used the bark of the birch and willow and other trees. Practically, cutch and gambier are now the only tannins used as dyes, and the value of a tannin to the cotton and linen dyer largely depends upon the *absence* of colouring matter. The following are the tannins ordinarily on the market.

Tannic Acid. This is prepared for the dyer from Chinese and Japanese galls, and comes on the market as pale yellow powder and as crystals. The commercial acid can be freed from its colouring matter by shaking it up with ether and allowing it to settle. The lower layer then is almost colourless tannic acid. It was considered necessary to use this tannin exclusively for delicate shades, but colourless extracts of sumach are now on the market and are less expensive.

Oak galls are produced by the puncture of a female wasp, and the richest in tannic acid come from Aleppo. *Chinese and Japanese galls* are produced by the puncture of an insect on trees of the *Rhus* family. These are not ordinarily used directly in dyeing, but for the production of tannic acid.

Knoppern are produced by the insect puncture of the unripe acorns of an oak grown principally in Germany and Austria. They are very rich in tannin, and the Germans use them largely in ink-making.

Sumach and Other Tannin Sources. *Sumach* is the leaves of certain species of Rhus which are ground up for sale. Sicilian sumach is the best, but it is very often largely adulterated, notably with the leaves of the lentisk. Sumach should contain 15 per cent. to 20 per cent. of tannin. It is a very hardy shrub, and flourishes in the South of England. A plant grown at Harrow was found to be comparatively weak in tannin, but the quality was very superior to the imported sumach. As there is a market for guaranteed pure sumach it might be profitable to grow it on waste land in England. It is very largely used in cotton dyeing, as the slight amount of red colouring matter it contains is not a disadvantage for many uses. A colourless extract is now on the market.

Myrobolans, sometimes written *myrobolams*, are the dried plum-like fruit of several species of trees, and are obtained chiefly from the *Terminalia* of India. The stones contain little tannin, and as they may amount to 50 per cent. of the weight of the myrobolans, this has to be taken into consideration in sampling. Myrobolans are cheaper than sumach and richer in tannin, but they contain a yellow-brown colouring matter which unfits them for light shade dyeing. They are largely used in dyeing dark shades and black on cotton and silk.

Valonia is the acorn caps of several species of oak grown in the Levant. They contain a dirty yellow colouring matter, and are little used by the dyer except occasionally in silk dyeing.

Trillo is a tannin consisting of the scales of the acorn caps. *Divi-divi* is the pod of a shrub grown in the West Indies: It is used in dyeing black.

Canaigre, the dried root of a species of dock, has been suggested as a substitute for sumach. It is very rich in tannin. The English dock was experimented upon, but the attempt to cultivate it as a tannin does not seem to have been successful.

A large number of other tannins, such as quebracho and algarobilla, are used by the leather tanner.

Oils. Olive and castor oil are converted into "Turkey red oil" or "sulphated oil" by treatment with sulphuric acid. Castor oil is principally used in England. It is decomposed with concentrated sulphuric acid, and the mixture of fatty acids resulting is washed with common salt and neutralised with caustic soda. It must be perfectly neutralised or slightly alkaline and is then soluble in distilled water to a clear solution. It is used as a mordant for basic colours in some cases, but the shades it gives, although brighter, are not so fast to washing as those got on a tannin mordant. It is indispensable in fixing mordants for alizarine dyeing. In the old process of Turkey red dyeing with madder rancid olive oil was used.

Fixing Agents and Assistants for Mordants. The mordants require to be decomposed, and the oxide, which is the actual mordanting agent, must be firmly fixed on the fibre. Wool is capable of decomposing mordants unaided, but, as in chrome mordanting, not without some injury to the fibre. Fixing agents, or assistants, are therefore added to the bath.

Caustic Soda. This is used sometimes as a solvent for alumina and stannic oxide. It is used in the production of *manganese brown*, also called *manganese bronze* or *bistre*, formed by fixing manganic oxide upon cotton. This colour is very fast to light and washing, and is now also obtained by steeping the cotton in a solution of manganous chloride, drying in the hot flue, and passing through a warm solution of potassium permanganate. Caustic soda also fixes ferrous or ferric oxide on the fibre, producing in this way two other mineral colours known as *iron-buff* and *nankin yellow*. It is very largely used in mercerisation, and at a certain degree of concentration has the effect of increasing the affinity of the cotton fibre for dyes.

Sodium Phosphate. This is a useful assistant with aluminium mordants.

Sodium carbonate finds many uses in dyeing. The *soda crystals* are the familiar "*washing soda*" of the household. In a crude calcined form the carbonate is called *soda ash*. It is largely used for softening water, for neutralising acids, and for fixing ferric and chromic oxides on cotton.

Sodium sulphate, or *Glauber's salt*, and *sodium chloride* or *common salt* may be considered together, as the dyer uses them for the same purpose. Neutral Glauber's salt should be in clear, transparent crystals, containing no iron. Calcined Glauber's salt is made by driving off the water of crystallisation, and very much less of this is needed in the dye-bath. Common salt and Glauber's salt are used in the dye-bath to retard the action of the colour, and thus secure levelness.

They are often used in large quantities, and raise very considerably the boiling point of the liquor, which has a beneficent action in some cases. In woollen dyeing they render the colour less soluble so that it is dissolved more gradually, and goes on the wool more evenly. Glauber's salt or common salt is very frequently the only addition to the dyestuff in dyeing with the direct cotton colours. In dyeing wool in acid baths, where dyestuffs are used whose colouring power is diminished by the presence of acid, Glauber's salt is added to restore the balance by diminishing the acidity.

Sodium bisulphate, or acid sodium sulphate, is used as a milder substitute for a mixture of Glauber's salt, and sulphuric acid. It is sometimes called *tartar substitute*.

Sodium sulphide is used as a solvent for the sulphur colours, which are insoluble in water alone.

Sodium phosphate is sometimes used in Turkey red dyeing as an assistant for aluminium mordants.

Ammonia is used for neutralising acids, and in all cases where the wool dyer needs a weak alkali. It is used for neutralising Turkey-red oil, as its volatility allows it to be readily driven off.

Ammonium carbonate is used for scouring wool, and as one of the best agents for fixing alumina on cotton.

Tartar emetic is largely used for fixing tannic acid in dyeing cotton with basics. It is *antimony potassium tartrate*, but is invariably called tartar emetic in the dyehouse. Its expense has caused many substitutes to be offered. *Antimony potassium oxalate*, known as *binoxalate of potash*, which is cheaper, may be used in some cases. A double salt —*antimony fluoride* and *sulphate*—has been sold for the purpose, and there are various patented preparations on the market.

Potassium ferrocyanide, known as *yellow prussiate of potash*, and *potassium ferricyanide, red prussiate of potash*, have been used as mordants instead of tannic acid. The yellow prussiate is used in dyeing aniline black. *Prussian blue* is perhaps the most important of the mineral colours. It is produced on cotton or silk by dyeing the material iron-buff [see Caustic Soda] and passing it through a weakly acid bath of yellow prussiate, and on wool by dyeing with yellow prussiate in a strongly acid bath at the boiling point.

Argol is the crude cream of tartar in the lees of the wine vat, and is red or white, according to the colour of the grape. It is added to mordants, especially to alum, the resulting double salt giving up more alumina to the fibre. The decomposition of the mordant with argol produces tartaric acid, which does not affect the dye-bath, whereas if sulphuric acid were used to decompose the mordant, and remained in the fibre in the dye-bath, it might injure both the colour and the material.

Calcium Salts. When *quicklime* is slaked, *calcium hydrate* is produced. Water dissolves very little of this, and the *limewater* holds particles in suspension. This is known as *milk of lime*. It is largely used in fixing iron mordants and in bleaching. *Carbonate of lime* or *chalk* is used in fixing alumina in alizarine dyeing, as lime in some form or other must be in the dye-bath. *Acetate of lime* is very frequently employed for this purpose, and also in dyeing with several of the natural dyestuffs. *Calcium chloride* is *bleaching powder*.

Acids. The mineral and organic acids are extensively used as solvents, neutralising agents, reducing agents for mordants, and for many other purposes.

Soap is used very largely by the dyer. It is a necessary assistant in many dye-baths, and the ordinary way of dyeing silk is to use a soap bath, plain or "broken," with acid. It is a very usual plan to "soap" dyed goods in order to brighten the colours. The dyer needs soap of a good quality, and, as a rule, neutral.

Quillaia, variously known as *quillaia bark, Panama bark*, or *wood* and *soap bark* is the bark of several species of Rosaceæ growing in Chili, Peru, and Brazil. It contains saponine, which has great lathering and cleansing power. The wool dyer uses it where soap would be inadmissible, and it has no harmful effect on the most delicate dyes.

Natural Dyestuffs. Local uses are made of a large number of natural dyestuffs even in the British Isles, but it is not practicable to consider any colouring matters of this class that are not ordinary articles of commerce. Even these are of less importance than before the days of the coal-tar dyes. The fight between natural indigo and artificial indigotin is still raging, and vat blue has already at least lost much of its great importance. Logwood, in particular, and cutch and fustic in a minor degree, retain a strong position. The rest of the dyestuffs here mentioned are driven from the extended fields they once held, but still find a restricted ground of utility.

The natural dyestuffs are drawn mainly from the vegetable kingdom; a very small group are of animal origin. The coloured oxides of many metals can be fixed on the fibre, but these are used as mordants, and the few mineral colours are of little importance in dyeing, and have been mentioned in describing the salts which produce them. Bancroft, whose "Philosophy of the Permanent Colours" was published in 1794, divided the natural dyestuffs into two groups—"substantive," those with which no mordant is necessary; and "adjective," those that could not be fixed on the fibre without a mordant. These terms are now used in connection with the artificial colours.

Indigo. Indigo, unfortunately, is decreasing in importance year by year. It was long looked upon as the queen of dyestuffs. Indigotin is the blue colouring principle in indigo, and artificial indigotin, only a commercial success during the last decade, has put the natural dyestuff more and more in the background. It is probable, nevertheless, that indigo will always find limited uses. The indigofera are very numerous, but the plants cultivated principally are I. anil, I. argentea, I. disperma, and I. tinctoria. The last of these is most extensively cultivated. The colouring matter of the woad plant, *Isatis tinctoria*, is identical with indigo, but the dyer uses woad only as a ferment in the indigo-vat.

Indigo is absolutely insoluble in water, but on treatment with an alkali and a reducing agent it is converted into indigo white, which dissolves in the lye. When cloth is steeped in the vat thus made, and exposed to the air or passed through an oxidising agent, the indigo blue forms on the fibre. In the woad vat the indigo is reduced by taking up the hydrogen produced by fermentation, and indigo white thus obtained is dissolved by slaked lime. Madder is used in this vat, which is employed principally for heavy woollens, and requires skill and experience. The zinc vat is used largely in England for cotton, and is perhaps the simplest of the indigo vats. Indigo, zinc, lime, and sometimes iron filings, are added to the water, which is kept stirred for 18 hours and then left to settle. The zinc decomposes the water and the hydrogen reduces the indigo, as in the case of the fermentation vat. The iron filings form a rough surface, aiding the evolution of the hydrogen, and form a galvanic couple with the zinc. A large number of vats are in use, each having advantages for a particular purpose. They all depend on the same principle of the reduction (or hydrogenation) of the insoluble indigo blue to the soluble indigo white:

$$\underset{\text{Indigotin}}{C_{16}H_{10}N_2O_2} + \underset{\text{Hydrogen}}{2\,H} = \underset{\text{Indigo white}}{C_{16}H_{12}N_2O_2}$$

The indigo white is fixed on the fibre, and on reoxidation is reconverted into the insoluble blue:

$$\underset{\text{Indigo white}}{C_{16}H_{12}N_2O_2} + \underset{\text{Oxygen}}{O} = \underset{\text{Indigo blue}}{C_{16}H_{10}N_2O_2} + \underset{\text{Water}}{H_2O}$$

The blue fixed on the fibre cannot be washed off again, and it is easy to see from this the great advantages and the one fault of indigo. It is very fast to light and washing, but the outer part of a fabric will lose some of its colour by rubbing. Indigo contains red, and generally some brown and yellow colouring matters in addition to the blue, also a body which becomes a sugary substance on decomposition in the vat, and a substance like gluten. These play a part in dyeing, but their exact nature is not known. They give indigo, however, properties that are absent in indigotin.

Some of the principal vats are as follow.

Copperas Vat. This is not so simple as the zinc vat, but it is cheaper, and English dyers have used it for cotton since the time of Elizabeth. The vat is "set" with indigo, copperas, (ferrous sulphate), fresh slaked lime, and water. In this vat the lime is an active reagent as well as a solvent for the indigo white. It combines with the copperas to form ferrous hydroxide, which reduces the indigo. The lime must be in excess to provide for its use as a solvent. This vat requires experience, and it is left to the experts who know how to humour it.

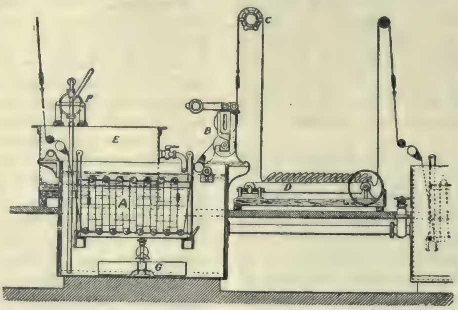
Hyposulphite or Hydrosulphite Vat. This is a modern vat very much in favour, as it can be used for both wool and cotton. Acid hyposulphite of soda is the reducing agent, and the dyer prepares this by the action of zinc on sodium bisulphite. The hyposulphite is prepared immediately before use, and added to indigo ground into fine powder and slaked lime. The vat is used cold for cotton and luke warm for wool.

Fermentation Vats. Woad has already been instanced and its action explained. Any substances, such as bran, starch, or glucose which will ferment may be used. Benoist and Collins actually make a culture of the ferment that produces hydrogen—*desmobacterium hydrogeniferum*—and add a trifling proportion of it to a vat prepared with food for it. The advantage of it is that this can be worked at a higher temperature than other fermentation vats, therefore it is more rapid in its dyeing action and more easily worked.

Stannous Hydrate Vat. In this, stannous hydrate, prepared by neutralising stannous chloride with caustic soda, is the reducing agent. It is said to be simpler than the copperas vat, but is little used in England.

The different vats have an influence on the shade; the woad gives the brightest shades, and the alkaline vats are best for the dark shades required for uniforms.

It has always been necessary, in view of the high price of indigo, to recover the unspent dye from the "bottoms." The copperas vat in particular is not exhausted. Many devices have also been used to combine indigo with other dyes to obtain its peculiar bloom and excellent qualities with less expense. A very usual plan is to "bottom" the goods with camwood or barwood first and afterwards with indigo, or the indigo is "topped" with suitable artificial dyes after a light shade of indigo has been obtained in the vat. These shades are termed "woaded" colours.



1. INDIGO PIECE-DYEING PLANT (Mather & Platt)

Natural indigo is holding its own best in woollen dyeing in the fermentation vats. Natural indigo is more suitable than artificial indigotin for use in these vats, which leave the wool with a softer feel than the chemical vats.

Indigo Piece Dyeing Plant. A special plant [1], patented and manufactured by Messrs. Mather & Platt, put indigo dyeing on a scientific basis. By its use the cost of labour and material is reduced and greater regularity in shade is secured than by the older processes. A practically clear vat is obtained, and the indigo which is taken up by the cloth during the process of dyeing can be replaced in such quantity as is necessary during the working of the vats. A saving of time is thereby effected, since the cages for stirring the vats have not to be raised or lowered. The plant for the production of dark shade comprises a range of four dye-vats and settling tanks. In the illustration one dyeing cistern only is shown. The cloth is taken through the liquor in the vats in the ordinary continuous manner, passing round the guide rollers of the cages, A, after which it is squeezed by the rollers, B. It is then laid by the wince in loose folds upon the slowly-travelling endless apron, D, where it is exposed to the atmosphere for a sufficient length of time for the indigo taken up in the previous vat to become thoroughly oxidised upon the fibre before the cloth enters the next vat, through which it passes in the same manner, and so on to the end of the range. The method of oxidising avoids all tension of the cloth. Curled selvedges and creases, with the resultant streaky dyeing, are thereby prevented. It also gives more time for exposure to the air, and thorough oxidation. The slack cloth between the vats acts as a perfect compensator, and prevents undue tension between one pair of squeezing rollers and the next. In connection with each vat there is a settling cistern, E, provided with a small hand pump, F, the suction-pipe of which goes to the bottom of the dye vat. The object of this settling is to remove regularly from the dye-vat the deposit which forms in working, and thus to keep the dye liquor clear, in this way avoiding the stains and uneven dyeing frequently caused by the accumulation of sediment in the dye-vat. When the work of dyeing is finished for the day, as the cloth runs out of the vats the mechanically-driven agitators, G, are set to work in each cistern for a few minutes, and allowed to rest until the next morning. Then the clear liquor is run back to the dye-vats from the settling cisterns —which have been filled up by the hand pumps the previous morning—by means of an outlet pipe fixed about halfway in the depth of the cistern. The sediment which has settled in the vats during the night is thus retained, and the indigo is recovered from it. Any of the chemical processes in use for indigo dyeing can be used with advantage in this plant, the one generally adopted being the zinc, lime, and hyposulphite of soda vat. The dye materials can be added to the vat as required while working, and can be accurately estimated. For light shades, the single vat shown in the illustration is sufficient.

Continued

THE CONIC SECTIONS

Definitions. The Parabola, Ellipse and Hyperbola. Properties Common to all Three Curves. Tangent and Normal

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MATHEMATICS
40
GEOMETRY

continued from page 5636

By HERBERT J. ALLPORT, M.A.

NOTES ON CONIC SECTIONS

Definitions. A *Conic Section* is a plane curve traced by a point which moves so that its distance from a given fixed point has always the same ratio to its perpendicular distance from a given straight line.

The given point is called the *Focus*, the given straight line is called the *Directrix*, and the constant ratio is called the *Eccentricity*.

Conic sections are so called because they are the curves in which a plane may be made to intersect the surface of a cone.

When the constant ratio is equal to unity—*i.e.*, when the distance of the moving point from the fixed point is always equal to its distance from the fixed straight line—the conic is called a *Parabola*. When the constant ratio is *less* than unity—*i.e.*, the distance of the moving point from the fixed point is less than its distance from the fixed line—the conic is an *Ellipse*.

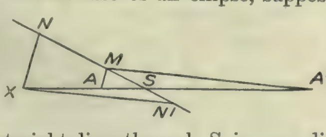
When the constant ratio is *greater* than unity, the conic is a *Hyperbola*.

The *Axis* of a conic is the straight line, of unlimited length, drawn through the focus, perpendicular to the directrix.

The point in which the axis meets the curve is called the *Vertex*.

The letters S, A, and X are used to denote the focus, the vertex, and the point in which the axis meets the directrix respectively. Remembering that A is the point which divides SX in the ratio of the eccentricity, it follows that a parabola has only *one* vertex, since there is only one point which bisects SX.

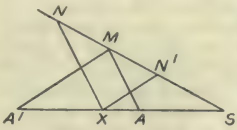
In the case of an ellipse, suppose the eccentricity is the ratio $a : b$, so that a is less than b. Draw a straight line through S in any direction, and measure off SM containing a of any convenient equal lengths, and MN containing b of these lengths. Join NX and draw MA || to NX.



Then (*Prop.* 52) SA : AX :: SM : MN :: $a : b$. Hence A is a vertex of the conic. But, if we measure MN′, containing b of the equal parts, *in the opposite direction from* MN, join N′X, and draw MA′ || to N′X, we again have, from the ΔSN′X (*Prop.* 52), SA′ : A′X :: SM : MN′ :: $a : b$. Hence A′ is also a vertex of the ellipse.

Thus, an ellipse has *two* vertices. Also, since a is less than b, it is evident that N and N′ lie on *opposite* sides of S, and therefore A and A′ also lie on opposite sides of S.

The second figure shows the same construction for a hyperbola. Here, since a is *greater* than b, N and N′ lie on the *same* side of S, so that the two vertices A and A′ also lie on the same side of S.



The middle point of the line joining the vertices is called the *Centre* of the conic, and the ellipse and hyperbola are called *Central Conics*.

Chord and *tangent* have the same meaning in the case of conics as in that of a circle.

The *Latus Rectum* of a conic is the chord through the focus, at right angles to the axis.

The *Normal* at any point on the curve is the straight line perpendicular to the tangent at that point.

The *Ordinate* of any point on the curve is the straight line drawn from it, perpendicular to the axis.

The parabola, ellipse, and hyperbola have several properties in common. Proofs of these are given. Afterwards, the principal properties peculiar to each curve will be noticed, but a thorough examination of them, and the proofs, would occupy too much space.

Properties of the Tangent

Proposition 72

If a chord PQ *of a conic meets the directrix in* Z, *then* ZS *bisects the exterior angle between the focal distances* SP, SQ.

Draw PM, QM′ $\perp$ to the directrix. Then the Δs PZM, QZM′ are evidently equiangular.

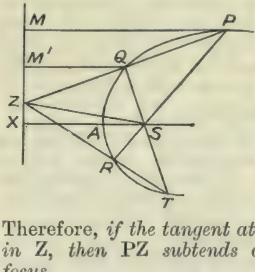
$\therefore$ PZ : QZ = PM : QM′ (*Prop.* 56).

But SP : PM = SQ : QM′ (*Def. of a conic.*)

$\therefore$ PM : QM′ = SP : SQ ;

so that PZ : QZ = SP : SQ.

Hence (*Prop.* 55) ZS bisects the $\angle$QSR, which is the exterior angle between SP and SQ.



Corollary 1. Suppose Q to move along the curve to P. Then PZ becomes the tangent at P, and since the $\angle$ZSQ is always equal to the $\angle$ZSR, we have $\angle$ ZSP = $\angle$ZSR. Hence, each is a right angle. Therefore, *if the tangent at* P *meets the directrix in* Z, *then* PZ *subtends a right angle at the focus.*

Corollary 2. If PS, QS meet the curve again at R and T, then, since ZS bisects the exterior $\angle$ between SR, ST, we see that TR must pass

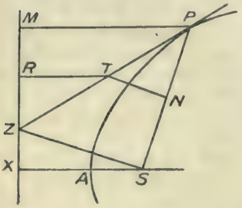
through Z. Also, when the line QT turns about S so that Q moves up to P, T will also move up to R, and ZR will become the tangent at R.

Hence, *the tangents at the extremities of a focal chord* (i.e., *a chord through the focus*) *meet in a point which lies on the directrix, and is such that the straight line joining it to the focus is perpendicular to the chord.*

Conversely, if tangents are drawn from a point Z on the directrix, the chord of contact will pass through the focus and be perpendicular to ZS.

Proposition 73

If, from any point T *on the tangent at* P, TN *and* TR *be drawn perpendicular to* SP *and the directrix, then* SN : TR *is equal to the eccentricity.*



For, PSZ is a right ∠ (*Prop.* 72).

∴ TN is ‖ to ZS.

∴ ZT : ZP = SN : SP (*Prop.* 52).

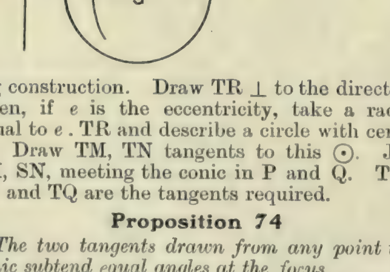
But ZT : ZP = TR : PM.

∴ SN : SP = TR : PM ;

or SN : TR = SP : PM = the eccentricity.

Corollary. To draw two tangents to a conic from a given point.

Suppose TP, TQ were the tangents. Draw TM, TN ⊥ to SP, SQ, and TR ⊥ to the directrix. Then SM : TR = SN : TR (since each ratio equals the eccentricity). ∴ SM = SN. Hence, a ⊙ with SM as radius and S as centre will pass through N, and TM, TN will be tangents to the ⊙. Thus, we have the following construction. Draw TR ⊥ to the directrix. Then, if e is the eccentricity, take a radius equal to e . TR and describe a circle with centre S. Draw TM, TN tangents to this ⊙. Join SM, SN, meeting the conic in P and Q. Then TP and TQ are the tangents required.



Proposition 74

The two tangents drawn from any point to a conic subtend equal angles at the focus.

Using the figure of the last corollary, we have to prove that ∠TSP = ∠TSQ.

Now SM : TR = e = SN : TR.

∴ SM = SN.

Hence the right-angled Δs SMT, SNT have a common hypotenuse and a side of one equal to a side of the other.

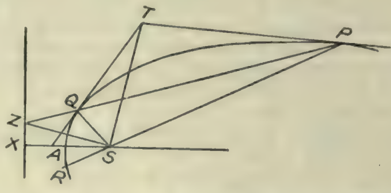
∴ the Δs are equal (*Prop.* 20).

∴ ∠TSP = ∠TSQ.

Proposition 75

If two tangents are drawn to a conic from a point T, *and their chord of contact meets the directrix in* Z, *then* TS *and* ZS *are at right angles.*

By Prop. 72, ZS bisects the ∠QSR, and by Prop. 74, TS bisects the ∠QSP.



∴ ∠TSZ is half the sum of the ∠s QSR, QSP, *i.e.*, half of two right ∠s. Hence TS and ZS are at right ∠s.

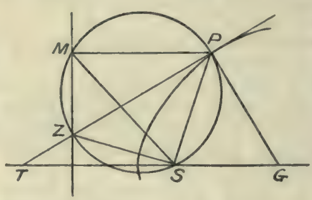
The Normal

Proposition 76

If the normal at P *meets the axis at* G, *then* SG : SP *is equal to the eccentricity.*

∠ZSP = a right ∠ (*Prop.* 72, *Cor.* 1).

= ∠ZMP.



∴ a ⊙ on PZ as diameter will pass through M and S (*Prop.* 39, *Cor.*).

∴ ∠SPZ = ∠SMZ (*Prop.* 40).

∴ the complements of these ∠s are equal, *i.e.*, ∠SPG = ∠SMP.

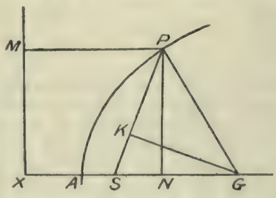
Also, ∠PSG = ∠SPM (*Prop.* 12).

∴ the Δs SPG, SPM are equiangular, and therefore similar.

∴ SG : SP = SP : PM = the eccentricity.

Proposition 77

If PG *is the normal at* P, *and* GK *is drawn perpendicular to* SP, *then* PK *is equal to half the latus rectum.*



In Δs SPN, SGK,

Right ∠SNP = right ∠SKG.

∠S is common.

∴ Δs are equiangular. ∴ they are similar.

∴ SK : SN = SG : SP

= the eccentricity (*Prop.* 76),

i.e., SK = e . SN.

But SP = e . PM = e . XN.

∴ SP − SK = e (XN − SN) ;

or PK = e . SX

= half the latus rectum.

Continued

Continued from page 5605

UNDERTAKERS

Although not strictly a shopkeeper, the undertaker may conveniently be classed under this category, for more often than not he keeps a shop for the display of some of his wares. In selecting this business for a career in life there are several special qualifications which a man must possess before he can hope to be successful. He must, first of all, be endowed with an abnormal amount of self-control.

How Experience is Acquired. There is no proper apprenticeship system in the trade. As a matter of fact, it is seldom that a youth sets out with the deliberate intention of becoming an undertaker. It is looked upon as a dismal calling, and one to be avoided. But it is a very necessary business, and one which, properly cultivated, yields a reasonable commercial return. In the Scotch country villages the joiner, as he is called, is also the undertaker, and the English village carpenter likewise does duty in the same way. The necessary experience is gained, therefore, by serving an apprenticeship preferably with a cabinet-maker. A youth would engage himself to a good cabinet-maker for five years, receiving a wage during that period probably varying from 3s. to 12s. per week. Having acquired a thorough groundwork in general cabinet-making, he would look for a position for two years or so as an improver at a wage of from 20s. to 25s. per week. By that time an alert man, with head and hands, would have all the necessary knowledge to fit him for a journeyman, earning an average of from 28s. to 35s. per week in the country or 40s. to 42s. per week in London.

Branches of the Trade. Generally speaking, the duties of an undertaker are to measure the dead body, to make the coffin, or to get it made, to arrange with the cemetery authorities, to provide the carriages and men, and to accompany the funeral to the grave. There are funeral furnishers, however, who do not come directly into contact with the mourners. They may be wholesale manufacturers or jobmasters, providing the undertakers with coffins, carriages, and all the appurtenances. In most cases the undertaker, however, makes and furnishes the coffin, and applies to a known carriage master for hearse and fittings. But there is a class of workmen who are coffin-makers pure and simple, and who are neither cabinet-makers nor carpenters. These men do not possess any great skill, and are often chosen more for their appearance and manners, as they have to assist their employers in coffining the body and at the funeral. Coffin-makers are paid from 6d. to 9d. per hour, according to the class of work they can do. There is no uniformity of hours possible, for coffins must be made at any hour necessary. The men in small establishments invariably accompany the funeral to the grave, but in big undertaking establishments (connected with a carriage-hiring business) there is a special staff of funeral attendants—often carriage washers and grooms—who are paid from 4s. 6d. to 6s. per job, and in addition a regular weekly wage of about 7s.

The Shop and the Workshop. Having learned all that is to be known about the business, and being in possession of the business qualifications named, good health, and a bank balance of at least £200, the young man—he should be at least 26 to 30 years of age—would look around for a suitable site to begin operations. First of all he would endeavour to secure a roomy, well-lighted workshop, preferably with an adjoining sale shop fronting the main street. Perhaps this will not be easily secured, and, if so, separate establishments within easy distance of each other would be selected. In any case the workshop must be dry and well lit, in a good locality, and within convenient access. Plenty of light is required for the work; even black stuff is "sore on the eyes." Such a workshop would cost £10 to £20 rental (or more if in London), and it would be divided into two portions. One part would be wood-lined, and fitted with shelves for the finished shells, for cloths, linings, or general ironmongery, all of which must be kept dry. The other division would be used as the workshop proper. It would contain one or two small benches with vices (costing £4 for two), half a dozen trestles for use in the shop, and the same number for use at funerals (£2); and, where possible, a small electric motor and a small saw-table. A motor (one-horse power) would cost about £14, a saw-table £12, and shelving about £5. The sale shop should be divided into a front apartment for callers, and a private room behind. In the front shop there had better be a small counter, a desk and a few chairs, shelving round the walls, and a few drawers. On the shelves there would be displayed wreaths, flowers, brass mountings, or anything else that could be exhibited. The drawers are for funeral stationery, and a selection of grave-cloths, shrouds and linings. The last-named must be kept dry, and, if possible, airtight, as the material is inclined to discolour on exposure. The fitting-up and display in the shop-window need not necessarily be dull or unduly sombre. The private room at the back should be fitted with a writing-table, chairs, and the usual office furniture. The fittings of the front shop and private room, including floors covered with floorcloth or linoleum, should not cost more than £20 all told, and the rent of both shops in conjunction would probably be £40 to £60 per annum, according to locality.

The Stock. As in most businesses, there are wholesale factors or manufacturers of the various articles required for the trade. There are manufacturers of all kinds of wreaths (artificial and natural), coffin furniture, special wood, mouldings, etc., for coffins, besides cloth, linings, and so forth. With regard to wreaths, it is often advisable for the

beginner to have an arrangement with a local wholesale florist, but, failing that, there are many regular wreath factors in the trade ready to supply all kinds of mementos on demand. For an opening stock, four marble wreaths, with stands, of assorted kinds, would be necessary. These would cost about £8 15s. Then six enamel wreaths would be ordered at a cost of about £1 16s., and one dozen preserved flower wreaths (18s.). A suitable selection of inscription glasses, vases, and graveside decorations could be obtained for £1. In stationery, funeral cards (such as are given to cord-holders and pall-bearers) would cost about 12s., while ordinary office stationery and books would absorb another £2 10s. That is all the stock necessary for the sale shop. For the workshop the stock would include 1 doz. assorted deals of oak, ash, and elm, cut to ¾ in. thickness (£5 8s.); 300 ft. of suitable mouldings (£1 5s.); 1 doz. deals of third quality yellow pine, red pine, or white pine (£3 6s.), and 40 yd. of lining for bottoms (£1 13s.). These would all be stacked, dried, and used as required. Then in cloths for covering or lining coffins, etc., there would be obtained one piece each of black (£2 5s.), white cotton (15s.), and embossed (£1 3s. 4d.), and half a piece of velveteen (£2 6s.). The black cloth is in 45-yd. lengths, the white and the embossed in 40-yd. pieces, and the velveteen in 30 yd. Besides these, there would be 2 doz. side-sheets (for placing up the sides of the coffin and folding over the body), one quality costing 10s. 6d. per doz., the other 7s. 6d.; ½ doz. embossed sheets (9s.), and four sets of best sheets (18s. 6d.). Frillings would cost at least 9s.; six shrouds would be 16s., and 1 doz. assorted grave-gowns £1 10s., while six sets of silk cords (£1 2s.) and 2 doz. sets of assorted cheaper quality cords would mean another sovereign. One piece of waterproof sheeting, which is often used in place of zinc lining would cost from 40s. to 48s. In ironmongery, two sets of brass mountings at £2 10s., two sets costing £2, four sets costing £2, and four sets costing £1 2s., would give a very fair selection. These might be assorted brassed, and nickle-plated. A "set" includes one name-plate, side-plates, and handles for cords, and where black coffins are used it will be necessary to have black or white mountings and lace. In such cases, four sets of black and four sets of white, for adults (3s. per set), and six sets for children (1s. 6d. per set), would suffice. Another 15s. spent on the ordinary nails, screws, etc., required in completing the work would furnish the ironmongery department, and practically complete the stock.

The Method of Procedure. When the relatives of the dead call, they should be ushered into the private room, where all particulars must be noted in a book kept for the purpose. These include the name and address of the person giving the order (for he or she is responsible in law for payment), the name, age and occupation of deceased, the cause and date of death, the name of the doctor who attended at the death, particulars of the burial ground, if any, when the coffining or "chesting" is to be done, the hour and day of the funeral, the service desired, the style, quality and price of coffin, and other questions regarding local customs or particular desires about which you may not be sure. In measuring the body, one must take the exact length, width at the widest, and the depth. The coffin should be made inside at least 2 in. longer and 1 in. deeper than the actual measurements. The finished coffin should be delivered punctually at the time appointed. With regard to screwing down the lid, local custom and the wishes of the relatives have usually to decide. The funeral arrangements differ in many localities, and it is the business of the undertaker to learn local customs. In lifting out or in, in public, the coffin must always be carried feet foremost.

The Question of Prices. Prices are affected by many things—wages, rents, facilities, and the character of the opposition. They should be neither too high nor too low, but commensurate with a good class of business. The ordinary charge for an adult coffin averages about £3; but for customers in a poorer station of life a lower charge should be made, without loss of profit, by reducing the quantity and quality of the materials and furnishings. Varnished pine coffins of better qualities and richer mountings average about £4 4s.; plain oak or elm, £8 or £9 if polished, and higher prices for the best quality and superior finish. Where cords and tassels with brass side plates are used, 15s. to 25s. would have to be added, and often the coffin requires a zinc lining, which would increase the price by about 12s. 6d., or, if soldered down, by about 20s. Attendance at an ordinary funeral is usually reckoned at £1; but where coffins are lined, extra assistance is required, and the charge would then be 30s. When country journeys or travel by rail are undertaken, the charge is usually 10s. per man and £1 for the undertaker himself, plus all outlays. Carriage by rail for a corpse is 1s. per mile, but an empty coffin is carried at the usual parcel rate. For undertakings to long distances hires may be wanted at both ends, and this increases the expense. The cost of hires will vary according to the style of funeral carriage and the horses. A plain hearse should run from 8s. to 10s. upwards per funeral, a pair-horse carriage from 21s. to 30s. or more. Single carriages for the mourners are usually hired at from 5s. to 7s. 6d. each, and pair-horse carriages from 15s. to 21s., according to style. A representative estimate for an ordinary funeral (shell and outer case), may be given somewhat on the following lines:

Inch elm shell, covered, lined calico, side sheets, ruffle, mattress, pillow, etc. A stout elm case, with capping and plinth, French polished, engraved brass plate of inscription, four pairs of brass handles, and closing screws. A funeral car and pair, brougham and pair, superintendent and bearers, price £14 10s.

Profits and Credits. The safe plan is to have a regulation scale of prices for coffins, which will include ordinary attendance, then add hires (from which a small commission is received), and out-of-pocket expenses. For an ordinary undertaking a clear profit of not less than 25 per cent. should be received. For such as call for a good class of oak coffin, with more stylish work, proportionately higher charges are made and greater profits accrue. The usual credit given by the wholesale trade is one month with 2½ per cent. discount. The undertaker should insist on doing a cash trade, for it is easier to get the money during the first flush of grief than later on, when the fountains have dried up somewhat. If there is any suspicion of pecuniary insecurity a surety or a deposit should be insisted upon, and no discounts should be given. When the payment of funeral expenses is to be made by a lawyer, a sum approximating to 6 per cent. interest per annum should be added to the bill, for legal luminaries are notoriously slow payers, and the poor undertaker may have to wait six, or sometimes even twelve, months for his money. In charging, it pays one to treat the deserving poor generously;

but where it is known that working people are members of funeral societies and other institutions of that sort prompt presentation of accounts should be made and payment insisted upon. The business would be worked, at first at least, by the undertaker and two men, with perhaps a girl to attend to the shop during the absence of the principal. Undertaking is a seasonal trade, the busy time being from November to April, though sudden rushes may be experienced at any time on the advent of cold winds, fogs, or epidemics.

Cremation. From a hygienic point of view cremation is regarded by public health authorities as preferable to earth burial, and the popularity of this form of disposal of dead bodies is slowly gaining in popularity. Statistics recently published show that the number of cremations in Great Britain during 1906 was 742, an increase of 138 on the previous year. But there is yet a deal of sentiment to be overcome before cremation can be universally adopted; moreover, the cost is prohibitive for people of ordinary means. There are several crematoriums in various parts of the country, the principal being in the neighbourhood of London. Woking and Golder's Green are, perhaps, the best known places, and the proceedings are under the direction of the Cremation Society. When a wish for cremation is expressed, application in writing must first be made to the company by the executors or nearest relatives of the deceased (unless the deceased has already communicated such a desire during his or her lifetime), stating that it was the wish of the deceased to be cremated, or that he, or she, entertained no objection thereto. Upon receipt of instructions, regulation application forms are sent by the Society, which are filled up and sent to the undertaker, who makes all the necessary arrangements. Two certificates from medical men (one of whom must have attended the deceased), stating the cause of death, are required, and the names and addresses of such medical men should be given in full. The Cremation Society reserve the right of refusing to carry out a cremation without assigning any reason. Cremations may take place two days after receipt of application form. The registrar's certificate is required, as in ordinary earth burials, and it is imperative that it be sent to the undertaker without delay, as the Society requires its production before the order for cremation can be issued. A pine shell, covered or polished, is sufficient to carry the body, and it is optional, when the body is about to be cremated, whether it be removed from the coffin or not; this is left to the decision of the chief mourners. Sometimes an ordinary outer oak case with the usual appointments is desired, but in these cases the outer coffin would not be placed in the crematorium. Cremation being considered only a process preparatory to interment, the Bishops of the Church of England have ordained that the Burial Service, which includes the committal of the body to the grave, should not be read until the ashes are brought to the churchyard for interment. This does not, however, preclude a service being held in the chapel, if desired, prior to cremation. This service consists in reading the Psalms and Lessons usually read at funerals and one or two of the collects from the Burial Service. The fee to the local clergyman, if retained, would be £1 1s. There are waiting-rooms for friends during the actual process of cremation, of which no inspection is permitted, and which usually lasts an hour and a half. The fee for cremation is usually £5 5s., alike for adults and for children. As a guide to cost, one might assume a cremation at Woking from London. There would be conveyance of the body from any metropolitan station to Waterloo, with hearse and men, railway charges to Woking, hearse and pair from Woking to crematorium, attendant from London, cremation fees, making necessary arrangements with Cremation Society, supplying casket and brass plate, in all about £15 10s. for net cash. In estimating, the undertaker would add charges for his personal expenses, and would leave a margin for any telegrams or incidental outlays that might be necessary. Cremations may be made to pay the undertaker fairly well; some companies offer inclusive terms to undertakers from £8 8s. upwards, but cremation undertaking is still an unusual occurrence in the career of an undertaker.

Embalming. Sometimes a request may be made to the undertaker to embalm a body which it is desired to preserve for a short time. In America embalming is a common practice. The process consists in treating the body so as to preserve it in its natural coloration by retarding decomposition. The usual method adopted is to make an incision in the carotid artery, and inject a solution of zinc chloride and salt. This fluid permeates every part of the organism, thus effecting the desired result and without leaving any unsightly traces of the operation. If the body is to be sent abroad or is to be kept for weeks, the quantity of the solution and its strength are increased and various incisions are made. There are several professional embalmers in London with whom undertakers may make arrangements. Their fees to the trade for an ordinary embalming (say preservation for a week), is about £5 5s. plus fares and expenses. The fees for a long period, ocean voyage and so on, are from £10 10s. upwards; while complete embalming would cost from £21 upwards.

WATCHMAKERS

In dealing with the watchmaking business we naturally include the vending of clocks. Watches and clocks have the same primary function to perform—namely, to indicate the time of day, and to a large extent, especially with the more valuable articles, their cases are made ornamental.

Timekeepers are classified under three heads—*watches*, *timepieces*, and *clocks*—the last-mentioned distinguished by having a mechanism for striking the hour either on a bell or gong. Watches and clocks are classified according to the use for which they are intended. We have chronograph, split-seconds chronograph, calendar, quarter-hour, and minute repeating watches. In clocks we have hour and half-hour striking, quarter striking, quarter chimes, and musical alarms.

Watches have each their technical name relative to their construction, as such lever, horizontal, duplex, chronometer, and verge. The last is, however, quite out of demand, owing to its primitive nature; too much friction is developed in the running, and the result is unreliability as a timekeeper for modern use.

Clocks are propelled either by a suspended weight, which gives the most accurate time, or by a mainspring coiled into a barrel or round box. A few—very few—are driven by electricity. The two first must be stocked, if you wish to complete your assortment. The most important and accurate piece of horological mechanism that science has been able to invent is the marine chronometer, swung in universal sockets, the effect of which is to maintain it in the same position continuously through all the violent

motions of a vessel in heavy weather. The marine chronometer, however, is the work of a specialist, and its use is limited. Therefore, you can dismiss it from the stock of an ordinary business, also the more complicated watches and clocks. They are rather expensive, and require very much greater capital than we submit to a beginner in the business with a moderate sum at disposal.

Capital and Position. Watchmakers in the retail branch combine jewellery with their own trade, and the jeweller vice versâ. Modern methods have compelled the two to combine. It is a rare thing to find a jeweller who is also a practical watchmaker, and the converse applies to the watchmaker. The two trades are taught separately, as they are run on distinctive lines. Still, it is possible for the member of one trade to possess a good theoretical knowledge of the other. So the reference to capital, site, etc., will be found under the title of Jewellers [page 3732], and it is applicable to either trade. But to go in for watches and clocks sufficient to make a variety, attractive and good in effect, another £100 is really essential, and even then you are able to stock only the less expensive, but everyday requirements, which are, after all, the best medium for any business.

Where to Buy. In the watch and clock business — especially the former — it is difficult to know where to buy; there are so many manufacturers, wholesale houses, and agents representing both home and foreign firms. The result is that the watch trade is cut up keenly, and the variation of 3d., 6d., or 1s. on a cheap watch is worthy of serious consideration. However, you can find out these discrepancies and their cause only after you begin business. You have not the remotest chance of doing so beforehand. If you are a practical watchmaker, you can easily distinguish the degrees of difference.

The two leading journals are the "Horological Journal," published by the British Horological Institute, Northampton Square, E.C., and the "Jeweller, Silversmith, and Watchmaker," published at 150, High Holborn. They contain information regarding the doings of the trade and the leading manufacturers' advertisements. Of course, there are many firms who do not advertise in them. You can find them out only by recommendation, or through being called upon. The latter method is really the most certain, for then you get into touch with them personally, and their stock. The usual terms applicable to jewellery may be had in the watch business also. Some firms are more rigid than others.

In a medium class trade, you are very safe in stocking everyday requirements, such as oxidised watches, both ladies' and gents', and wristlets. Avoid the hunter or double-case watch—silver and gold also; but of those principally the latter metal in ladies' size. In some districts gold watches can be sold better than silver watches. Then there are the gold-filled, gilt, and nickel, with all of which be very careful. The field for them is chiefly in America and the Colonies. Complicated watches can be left over till you see how things progress. Under-buy rather than over-buy. Overstocking is a dangerous rock on which you may get wrecked at the outset of your career.

Exercise your own judgment when buying, and do not accept the free and pushing advice in toto of your genial commercial's flattering words: "They are selling," "We are doing well with them," "You are sure to sell them," etc., plus the offer of tempting terms. Clocks must be carefully studied also. For instance, in the large cities marble clocks are at a discount, but in the smaller and country towns they are still much in demand. City customers prefer the light and more dainty variety. The kitchen alarm, the small fancy clocks for sitting and bed rooms, are a very sure stock. Here, also, have variety more than quantity to begin with.

Stockkeeping. The care of your stock is exceedingly important. The difficulty is to impress that fact upon the mind of your assistant. See that all finger impressions are removed at once both from the outside and inside. It is the inside of the case that is often neglected. You may find that at an unexpected moment. When showing the article to a prospective purchaser, you open it and perhaps find a finger stain or two, and are unable to remove it on account of the perspiration having eaten into the polished surface. Needless to add, it conveys its own meaning to your customer, with a probable loss of sale. The same remark applies to clocks, especially fancy brass and nickel ones.

Profit varies from 25 per cent. to 50 per cent., all according to the nature and cutting competition of the watch. In reckoning out your profit you must consider not only your running expenses, but also take into allowance the quiet seasons of the year. Watches, clocks, and jewellery are not necessaries of life, and with a slump in the business market of your district you will be one of the first to suffer. Therefore, you are justified in trying to get your 33⅓ per cent., which you can.

Repairing. This branch of the watch business is one of great importance, and if you are a practical man you can employ your spare time in doing a proportion of your own repairs, which certainly helps to meet your expenses. You are also able to detect faults at once in either the watch or clock brought in for repair.

Do not work your repairs under cost, although you have to come and go a little in some cases. Do not attempt to compete with the individual who works unreasonably cheaply. No watch that is valued reaches his hands. Guarantee all that you undertake. If you feel not justified in guaranteeing an article, say so, but offer to do the best possible.

WINE AND SPIRIT MERCHANTS

Under no circumstances may a shopkeeper sell excisable liquors for consumption on the premises, but the trade for consumption "off" is considerable and growing. Legally, the conditions are very similar to those of the licensed victualler [see page 3734], except that the minimum and maximum quantities of sales are subject to control.

The business of the wine and spirit merchant is usually purely a matter of buying and selling proprietary goods supplied by the dealers. But little bottling is done by the merchants, because public consumption, as a rule, is confined to more or less well-known brands. A lower division of the business is that in which draught beer is sold.

The wholesale side, which is outside the scope of these notes, as needing large capital and experience, is represented by the wine and spirit dealers, who are frequently also licensed distillers and rectifiers of spirit. They sometimes enter the retail trade (or the retailer adds the wholesale business to his own), and have the privilege of exemption from the necessity of obtaining a justices' licence for premises without intercommunication exclusively used for the sale of excisable liquors and other drinks. All others (except the favoured university chancellors, the vintners of the City of London, and the mayor and burgesses of St. Albans) must have a justices' licence before an "off" excise licence can be granted.

Much information relative to the off-licence trade is given in articles on the Licensed Grocer [page 3045], and on the Licensed Victualler [page 3734], and they should be read in conjunction with the present notes.

Employees. Employment in the trade does not offer very bright prospects. A start is usually made as a boy or learner behind the counter in a large business, at from 5s. to 7s. per week. When some knowledge of the articles dealt in, the different brands, their sources, etc., has been obtained, the position of counter hand at about £1 a week may be filled, until sufficient experience has been acquired to enable the embryo merchant to manage a small off-licence, probably a branch. Brewers and dealers frequently run retail businesses under managers. The remuneration will not be more than from 25s. to 30s. a week, with a commission on trade exceeding a fixed amount, subject to the rate of gross profit being maintained. House accommodation is generally given if the shop is not a lock-up one.

An alternative, and perhaps better, method of getting the knowledge and experience is by working up in the wholesale cellars. An enterprising man will get much information in regard to wines and spirits in bulk, bottling, and other processes, so that he may proceed to the higher branch of the trade if opportunities offer. He will lack the retail experience, but a smart man will be able to act as counter hand and soon make up his deficiencies in this respect.

Capital. More cash is required by the beginner in this trade than in the very similar trade of the licensed victualler. The system of tied houses does not prevail (except among some of the draught-beer businesses), and consequently brewers and distillers do not often assist the licensed shopkeeper, the trade, moreover, not being so great a security nor the goodwill so valuable as in the case of the publican. Another important reason is that the trade is largely credit, and a considerable proportion of the capital will always be represented by book debts.

A moderate-sized suburban business, the trade of which, when well worked, should amount to about £50 a week, may be taken as an example of the type for the beginner. The lease, fixtures, and goodwill of such a business would be purchased for from £300 to £350. A business of this character and price may have been somewhat neglected. It would hardly be possible to buy at this figure if it were actually turning over £50 weekly, but it should be possible, by pushing the trade, to bring it quickly up to the £50. If the actual turnover be less than £25 or £30, the business is hardly likely to prove a good investment, even for the purchaser of the type we assume—a man of energy, ability, and enterprise.

Fixtures, fittings, and trade utensils will account for from £50 to £75 of the capital. The value of the lease will vary according to its age and the rental value. The "off" trade is not so personal as the "on," so the goodwill is less costly.

The remainder of the total capital of about £1,000 which will be necessary for this type of business will be represented by stock and the book debts above referred to. Unless a considerable amount of cash is at the retailer's disposal he will lose the discounts obtained by buying in large quantities, particularly spirits, which represent the greater proportion of his profits.

For higher-priced businesses it is simply a case of multiplication. As they get bigger the capital required rises in fairly exact proportion, up to as much as £20,000, when the merchant usually becomes a dealer and licensed rectifier. With regard to entirely new businesses, remarks similar to those made in respect to publicans apply, the difficulty being to get magistrates to grant new licences.

The Shop. The most profitable class of small business in this trade is that afforded by a shop in a suburb with houses of the average, or middle-class type. There will be no draught beer trade in such a business. The usual site conditions for business success apply. The site should be in a main, or other busy road, and preferably at a corner for display purposes. The ideal shop would be double fronted, and have a side entrance for a hand-cart or truck, and for direct access to the roofed outhouse storing accommodation, which is most useful for empties, crates, etc., but which rarely exists, however.

The shop should be lofty and well ventilated, so that the atmosphere may be as free as possible from the varied odours peculiar to the wine merchant's mixed stock. It must not, however, be draughty or cold, or the shop stock will be affected, as explained in the two previous articles, in regard to temperature conditions. A lock-up shop will be cheap, and there will be no rates on high business premises assessments to pay, as these are discharged by the owner or house occupier. A railway arch is frequently available for a lock-up shop, and is cheap, but is not to be recommended, for some reasons which are obvious. A shop with a house is more usual, and is provided for in the capital here estimated. The offices of the broker are almost as indispensable as in the case of the licensed victualler, and the remarks made in regard thereto apply equally here.

Fittings. The fixtures and fittings should include plenty of shelves and bins, a good counter, window fittings, and a hand truck. Beer-engines will be an extra expense. The window should be of the cased, airtight pattern, for, apart from artistic cobwebs, a display is spoilt if the bottles get dusty. The shelves, pyramids, and stands should be adaptable and not fixed, for the window display will be of little value if it is not possible to change it somewhat frequently and push different lines in turn.

In the shop there should be good counter space and plenty of shelving and bins. Bottles of wine are laid in alternate horizontal layers, the first bottoms outward, and the next necks outward. Beer must be kept standing upright for sediment to deposit. Spirits are also usually kept upright. A cellar will, of course, be advisable for casks, and necessary if draught beer is sold. Cellar hints and stocking conditions have been previously given.

The Retailer's Licences. The principles on which licences are applied for and obtained have been fully described in the two preceding articles. It is to be noted that by the 1902 Act the justices' discretion in regard to granting new retail off-licences is absolute, and this also applies to the renewal of off-licences granted after June 25, 1902. This is in considerable contrast with the licensed victualler, who may be refused his licence only on one or more of four specified grounds, and on compensation.

The wine and spirit merchant may sell his goods under various justices' and excise licences. Wine is sold by retail under an off-licence granted to shopkeepers under the Refreshment Houses Act (cost, £2 10s., expiring April 1), but only in reputed pints and quarts and less than 2 gallons or 1 dozen

quarts at a time. This includes sweets. The owner of the wine-dealers' licence (cost, £10 10s.) may sell any quantity of wines or sweets. The off sale of beer is licensed to householders under the Wine and Beer Acts (cost, £1 5s.). The beer and wine retail off-licence (£3) is a combined licence. Spirits for off-consumption are sold in Scotland and Ireland under what are called "grocers'" and "spirit-grocers'" licences (cost, Scotland, from £4 4s. to £13 13s., and, Ireland, £9 18s. 5d. to £14 6s. 7d. respectively. In England it is necessary first to take out the spirit-dealers' licence (£10 10s.), and then the additional licences to retail off, liqueurs (£2 2s.) or spirits and liqueurs (£3 3s.).

Legal Conditions. As has been previously indicated, the way of the licensed vendor of intoxicants is by no means easy, nor his legal path straight. Heavy penalties await the off-retailer in many directions if he commit an illegality, by overstepping the limits of his licences, or his selling hours, by permitting drinking on the premises or highway adjoining, or by allowing his goods to come under the operations of the Sale of Food and Drugs or Merchandise Marks Acts. Care is especially needed to ensure that the sale of excisable liquors takes place on licensed premises "within the meaning of the Act."

The holder of an off-licence who accepts orders for beer given to his carman at customers' own houses, the beer being then delivered at the door and payment received there, can be convicted of selling liquor at an unauthorised place, unless the specific goods supplied are appropriated to the order at the licensed premises. For there is no sale in law while it is uncertain to what particular articles the contract applies. If the order is received and accepted at the shop and the goods there appropriated, the sale is on licensed premises, although delivery and payment are at the customer's house. Taking orders without an excise licence—for instance, at an unlicensed branch to be executed at licensed premises—is illegal, except in the case of *bona fide* travellers. A fresh licence is required for each set of premises.

Profits. Since the trade consists so largely of bottled goods of proprietary origin, it follows that price-cutting is rampant and profits reduced to a limit. People will only drink what they know—that is, what is well advertised. Price-protection agreements are, however, now required and enforced by the manufacturers of several branded goods.

The average gross profit, calculated on the turnover, will not be more than 15 per cent. It may be a little more with a draught beer trade. Even these profits are possible only if the merchant is in a position to buy largely in order to get full discounts. An example of these discounts may be taken. Proprietary articles should be bought from the makers and in gross lots. Many of the proprietary Scotch whiskies in demand, selling at 42s. per dozen, cost 36s. Off this, for a gross order, 1s. a dozen will be allowed; if delivery is within, say, a ten-mile radius (London), so that the goods may be delivered loose in baskets instead of packed in cases, a discount of from 1s. to 2s. will be given; and then a further allowance of 1s. per dozen for bottles returned. The cost is thus reduced to from 32s. to 33s. This is entirely dependent, however, on cash payments—within a month or so.

Working the Business. We have assumed a business affording scope for development and a man of the requisite capability and energy. Such a business is to be worked up only by energetic, careful and well-thought-out canvassing. The owner of the business must himself, if, as is probable, his staff is insufficient, spend a part of each day going out to get orders in the neighbourhood. He must, of course, be careful not to hawk any goods; the penalties are heavy.

Circularising is of considerable assistance, but it must be properly done, not too promiscuously. It is most effective when it takes the form of a well got-up price list, personally addressed. The list need not be costly, but it should be well printed (without expensive half-tone blocks) and well arranged, so that reference is easy. An important point is the perfection of methods of delivery. The larger proportion of the business will be orders for delivery. Two boys at 5s. or 6s. per week should be employed for truck delivery, so that promptness and reliability may be ensured. Care should be taken that the delivery is not at such inconvenient times as meal-times, late at night, or on Sunday mornings.

Bottles not returned by customers represent one of the largest sources of loss in the trade. Frequently customers cannot be charged for these empties, and the retailer has to be content with the loss. Beer bottles not returned to a wholesaler are always charged to the retailer's account. Aerated water bottles are not so charged, the manufacturer in London getting back his bottles by means of a special bottle clearing-house. In the case of wine and spirit empties, non-return usually means the loss of the return allowance. All goods delivered on order should be accompanied by a delivery-slip stating clearly the number of bottles, etc., sent out and returned. This is made out in duplicate from a book for the purpose, one slip being sent to the customer as a delivery note, and the other filed. Deliveries and returns are checked, and then entered to the appropriate accounts in a specially ruled ledger. The specimen ruling for such a special ledger given here combines the empties and cash accounts particulars in a comprehensive but simple form, and obviates the necessity for keeping separate sets of books. On the debtor side of the account entries in one or more of five columns give particulars of the goods supplied, their price being entered in the cash columns. The credit side shows empties returned and cash paid.

It is a good plan to allow the delivery boys a small percentage on empties collected, and also to fine them for breakages. Much wastage is caused by breaking, which would be avoided by careful stocking methods.

Dr. — Mr. JOHN JONES, 48, Queen's Road, Peckham. — Cr.

Date.	Casks.	Wine, Spirit, and Beer Bots.	Syphons and Aerated Water Bots.	Cases.	Sundries.	Folio.	£ s. d.	Date.	Casks.	Wine, Spirit, and Beer Bots.	Syphons and Aerated Water Bots.	Cases.	Sundries.	Folio.	£ s. d.
1907.															
January 5..			1 doz. mineral				1 6	January 2..	1 firkin		1 doz. mineral				
	1 firkin ale						11 0	February 24		6 wine pints	4 syphons	2	1 jar		
,, 10..		1 doz. spirit					2 8 0	March 10 .		1 doz. spirits	2 doz. splits				2 0 0
					1 jar		16 0								
		6 wine pints					4 0								
February 2..			2 doz. splits	1			2 0								
			4 syphons	1			1 6								

Cyclopædia of Shopkeeping *concluded; followed by* Retailing Enterprise

Continued from page 5634

By Professor R. ELSEY SMITH

THE properties of iron and steel, and the method of manufacturing them, have been already dealt with in the course of MATERIALS AND STRUCTURES, and the form of girders and stanchions, steel framed structures generally, and steel roofs have been considered in the same course. The method of pattern making and casting, particulars of the tools used by the smith and the manner in which his work is executed, including the work of riveting, have been described in the course of MECHANICAL ENGINEERING. This article will deal, therefore, not with the preparation of the materials and articles used in connection with the building trade, but with the manner in which they are fitted and applied in a building.

Stanchions and Columns. These are prepared by the iron manufacturer, and sent to the works ready for fixing. They are delivered in carts, and the builder is responsible for unloading them, and for storing and protecting them, if necessary, before they are fixed. In important buildings, where there is a derrick, this is used for unloading all such heavy goods, and, if the bases to receive them are prepared, they may be lifted and deposited close to or on their permanent position. Care must be exercised in unloading either stanchions or girders to see that the flanges are not damaged during the process; this may easily happen if the lifting chain is passed round the stanchion and bears on the edges of the metal flanges; it is necessary, therefore, to insert wooden packing pieces round the object to be lifted at the point where the chain is placed, so as to prevent this direct bearing on the edges.

Where there is no crane on the premises the work of unloading is slower, and more laborious. Several men will be required; the number will depend on the weight and size of the object. It is often necessary temporarily to fix up an inclined way from the level of the tail of the cart or lorry, so that the stanchion may be lowered with the help of wood rollers to the ground level, and afterwards shifted to its required position in a similar manner; a series of short wood rollers is placed beneath the stanchion during this process to facilitate moving.

Hoisting into Position and Fixing. Some form of tackle is required for lifting the stanchion into a vertical position, and depositing it in its permanent place; this must be temporarily fixed conveniently for dealing with the stanchion, and may be supported by a scaffold-pole, or timber baulk, which is carefully strutted or stayed in the required position.

The seating prepared for either a stanchion or column is usually a stone template [see Masonry], and the base plate has its under surface planed true, but it is not laid in actual contact with the stone. Sometimes a sheet of lead is used as a pad, but for many purposes a cement bed is formed. For such a bed the stanchion is placed in position above the template, leaving a space of from ¾ in. to 1 in., and is carefully tested with a plummet to ensure that it is truly vertical. Wedges are driven in between the base plate and the template, and the plate has a little barrier of kneaded clay formed round it on the template; one or two holes are perforated in the plate, and through these cement grout is poured, which spreads all over the area covered by the base plate, and this is continued till the space is entirely filled up, and a perfect bearing between the stone and iron is thus secured when the cement sets [1]. As soon as it is set the clay wall may be removed and the wedges cut off.

Anchor Plates and Bolts. If an anchor plate and holding-down bolts are required to be built into the pier, a wood template or pattern of the base plate is obtained, with the position of the bolt holes cut in it, and the anchor plate is bedded with the bolts inserted in it, their position fixed by the template, and the brickwork built up around them. They are also passed through perforations in the stone template ready to receive the base plate; the upper ends are threaded, and after the stanchion is bedded, nuts are applied and tightened up [2]. In forming concrete piers a space is sometimes formed round the bolts to allow of a little play in their position if required, and afterwards these spaces are grouted in cement.

Size of Base Plates and Templates. The area of the base plate in such columns and stanchions is generally considerable in relation to the plan of the column or stanchion in order to provide a broad and steady platform for it to rest upon; it is, however, important to see that it is of such an area in relation to the total load it carries that it does not put any undue load upon either the template or the pier under it.

For example, supposing a stanchion with its load exerts a pressure of 50 tons, that the stone of which the template is formed may be safely loaded to the extent of 20 tons per foot, and that the brickwork may be safely loaded to the extent of 7 tons per foot. The smallest area of the bed plate must be $\frac{50}{20} = 2\frac{1}{2}$ ft. super.—that is, if the support is square in shape it must be 1 ft. 7 in. square. The size of the template must be $\frac{50}{7} = 7{\cdot}14$ ft., or about 2 ft. $7\frac{1}{2}$ in. square, and this will also be the smallest brick pier suitable for such a load under the conditions. In practice, the base plate is often made much nearer to the area of the template.

Where a load has to be brought down on to a wall instead of on to a square pier, both the template and base plate must be adapted to the situation, and made, not square, but elongated, so as to distribute the load over a sufficient area of walling.

Girders. In the case of girders one or both ends may be carried on stanchions, or on brick or stone piers or walls. In the latter case a stone template must be provided to distribute the concentrated load due to the girder over a considerable area of brick wall or pier [3]. The size of the template will depend on the load it has to distribute and the strength of the walling: the area of the flange which rests on the template will depend on the effective load on the end of the girder, and the safe load per foot that may be placed on the material of which the template is formed. It is very important that a sufficient length of girder should rest on the template

to ensure that it may not be overloaded and cracked. The ends of girders are very usually laid on a lead or thick felt coating [3].

For example, supposing one end of a loaded girder exerts a pressure of 25 tons on a wall, that the stone of which the template is made may be safely loaded to the extent of 20 tons per foot super, and that the brickwork may be safely loaded to the extent of 7 tons to the foot super. The area of the flange resting on the template must equal $\frac{25}{20} = 1\frac{1}{4}$ superficial feet, so that if the width of the flange is 15 in. it must rest for at least 12 in. of its length on the template. The area of wall over which the template must distribute the load equals $\frac{25}{7} = 3{\cdot}57$ ft. The shape of it will depend on the thickness of the supporting wall, if this were 18 in. thick, the length would have to be nearly 2 ft. 6 in. If the end of a girder rests on a stanchion or column instead of on a brick wall no template is required, as the area of the head is made ample to receive the load, and the girder is often secured to the stanchion by bolts and nuts [**4**]. When this is done the holes should in every case where the girder is liable to expansion and contraction with changes of temperature be in the form of slots to allow of a slight movement.

Putting Together Roof Principals. In dealing with roof principals, these are usually delivered in separate pieces, as they are too cumbersome to move by road when put together. It is usual to form a platform of scaffold boards at or about the roof level, and on this these principals can be put together; they will have been previously fitted up at the manufacturer's yard, and should be refitted with little difficulty, but some small adjustments may have to be made, and sometimes additional holes drilled to ensure the work coming together perfectly.

The principals are put together in a horizontal position on the platform described, and are then hoisted into a vertical position and lodged on the templates prepared for them. In preparing the templates allowance must be made not only for the weight of the principal and the roof it carries, but for the possibility of a heavy load of snow and the effect of wind pressure.

The foot of each end of the principal is very often secured to the wall by means of holding-down bolts and an anchor plate built in at a lower level [**5**]. These are similar to those described for the bases of stanchions; the plate is built in by the bricklayer, and the wall is constructed with the holding-down bolts, which are brought up in the thickness of the wall, passed through the template and the foot of the principal, and the end provided with a screw for the nut.

Fitting Purlins. The purlins, in the case of roofs with iron principals, may be of either iron or wood [**5**]; the former are generally bolted to the back of the principal, but wood purlins are fixed with bolts or screws to iron chairs bolted or riveted to the principal, and taking the place of cleats in an ordinary timber truss. Brackets may also be required, bolted to the head of the truss to support the ridge piece.

Ironwork to Timber Roofs. Most timber roofs depend—partly, at least—on fastenings provided by the smith. These consist of bolts or straps of various forms, for strengthening the joints between adjoining timbers, and in some cases shoes and heads are also required.

The fastening between the tie-beam and principal rafter is best made with a stirrup strap [**6**], and the particulars must be supplied to the smith by the carpenter. The strap is of wrought iron, which should be ductile, and capable of bearing a tensile strain of 20 tons per square inch; it passes round the tie-beam, and is broad and flat; the size depends on that of the roof. At each end of the strap a bolt with a tapped end is forged on, so that when in position these two ends will stand up beyond the back of the principal rafter. To ensure a true bearing for the strap, when it is not desired to cut the timber of the tie-beam, a bearing plate of iron is formed, which is secured to the under side of the tie beam by spikes, and may have the end turned up and let into the under side.

A back or cover plate is provided with two perforations; this rests on the back of the principal, and the perforations allow the ends of the strap to pass through, and these are tightened up with nuts. The strap is very often placed at right angles to the slope of the principal rafter, but may be inclined at an angle to it, and pass round the heel of it, which must be cut, and this will require the bearing plate to be at a different angle.

Another method of fixing such a stirrup strap is to pass the loop round the heel of the rafter and to secure the two ends by a bolt passed through them and the tie-beam, but this does not permit of tightening up the strap should the necessity arise.

For small trusses a strap is sometimes dispensed with, and a bolt used; in this case, as the two bearing surfaces are not parallel, a bevelled washer must be provided on the under side of the tie-beam, against which the nut can be screwed.

Ironwork at Foot and Head of King Post. A somewhat similar strap is provided for fastening the tie-beam and king or queen post. In this case an enlarged head is formed at each end of the strap, and a slot is formed in this; irons, termed *gibs*, are provided and placed at each end of the slot. These secure the strap close to the post on each side, and give a level bearing for the iron *keys* or *cotters*, which are driven in to draw up the strap and the tie-beam it carries [**7**].

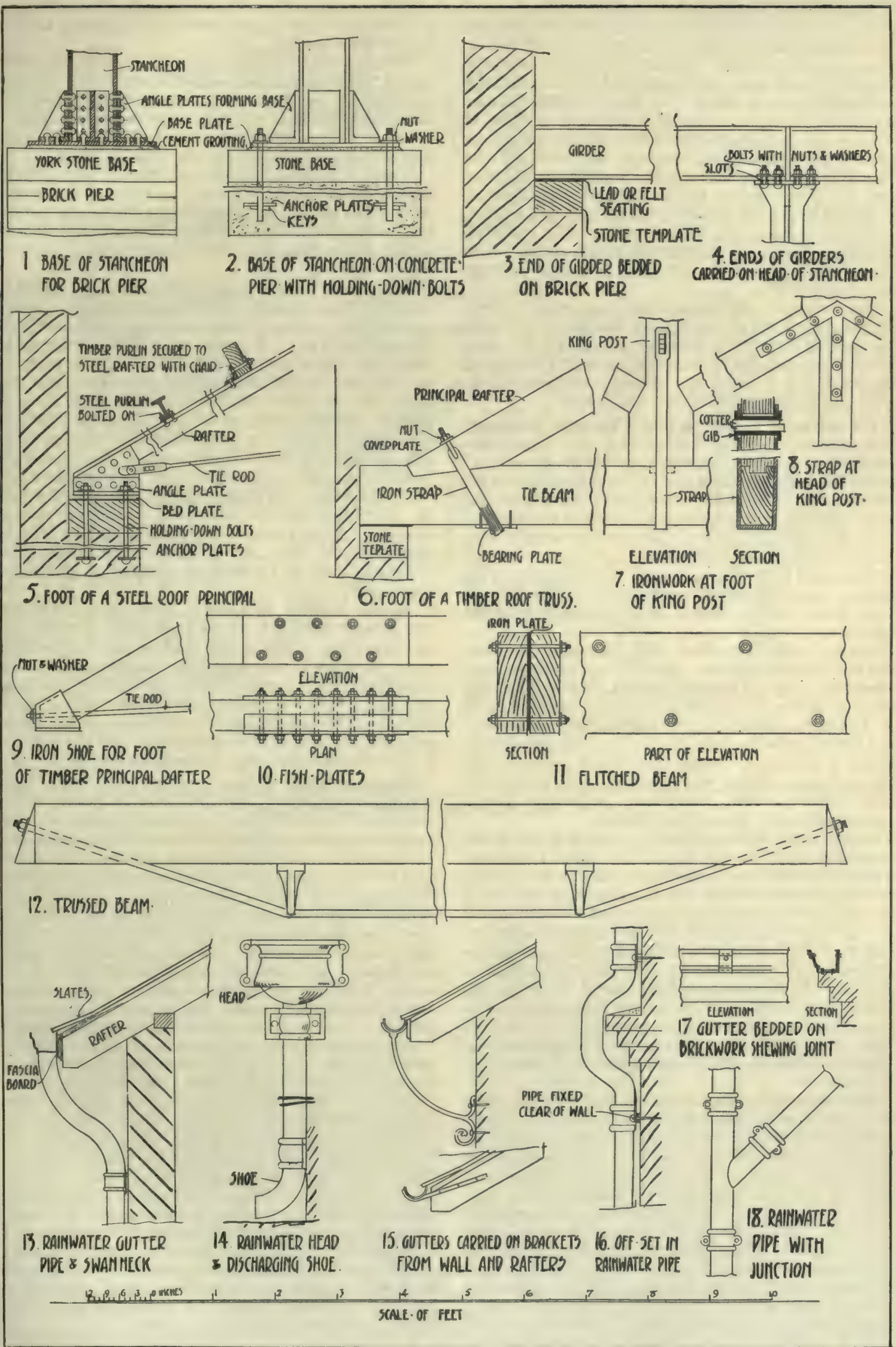
Straps are also required at the head of the post to unite the post with the timbers butting against it at this point. These straps are made in two parts, identical in form, and are placed one on each side of the timbers, and bolted together by bolts passing through holes provided for them in the straps and in the timbers, and secured with nuts [**8**].

Any bolt-head or nut that bears against a timber surface must be provided with a washer—that is, a stout plate of iron, generally circular, with a perforation for the bolt. This is placed between the timber and the head or nut, to increase the bearing surface, and to avoid damaging the fibres of the timber. When the roof is exposed to view the edges of these washers may be ornamentally cut and slightly raised for the sake of appearance.

Straps are also often required in collar beam roofs to secure the collar to the principal rafters, and this takes the form of a stirrup strap placed horizontally round the back of the principal, and bolted to the collar with bolts and nuts.

All straps and bolts used with timber work require protection against corrosion. One method frequently adopted is to heat the metal to a blue heat and dip it in linseed oil, or dash the oil over it if dipping is inconvenient. All such ironwork should, however, be painted with two coats of oil colour before fixing, and should be painted periodically.

Similar straps to those described for roofs are often employed in framed partitions; but where bolts can be properly used for securing joints in partitions, this is preferable, as projections on the face of the timbers interfere somewhat with the plastering.



STRUCTURAL IRONWORK AND RAIN-WATER FITTINGS

Roofs of Timber and Iron. In compound roofs, formed partly of timber and partly of iron, the tensional members are of iron or steel; those in compression of wood. In some examples only the king or queen posts are replaced by bolts, and the tie-beam is left of wood. In the first class of roof a cast-iron head must be provided with sockets to receive the ends of the principal rafters, which are housed into them, and through the head an iron bolt is passed provided with a head at the top, and the lower end is taken through a perforation in the tie-beam and provided with a nut and washer.

If the tie-beam is replaced with a rod a cast-iron shoe is also required for the foot of the rafter, which is housed to it, and the rod itself is passed through the shoe [9].

These various iron fittings vary somewhat in form with the pitch of the roof, and in size according to the span of it and the strength required; but they include the principal fastenings used in timber and composite roofs, and the illustration referred to gives examples of the forms described.

Ironwork Used with Timber Beams. Iron plates, termed *fish plates*, are sometimes required when two timbers have to be united end to end [10]; they are flat plates, the same width as the timber, and the tensile strength of the upper and lower plates together must equal that of the timbers they unite. The two plates are perforated with holes exactly corresponding with perforations in the timbers, and bolts with nuts and washers are used for uniting them. The two ends of the plates may be bent down, and let for a short distance into the substance of the beams.

Similar bolts, provided with nuts and washers, are required for uniting the timbers of a built-up bressumer, and are passed through from side to side, so as to unite the timbers; in some cases an iron or steel plate, or *flitch*, is inserted between the timbers and bolted in with them [11]. The flitch is usually about ½ in. less in depth than the bressumer, and the thickness is from one-tenth to one-twelfth the total width of the bressumer, while the length corresponds with that of the timbers.

Beams may be considerably stiffened when the bearing is long by the use of iron rods, forming a truss below the level of the beam [12]. A cast-iron shoe is provided at each end of the beam, or the end is cut in a plane at right angles to the tie-rod, and a strong plate fitted over it. A cast-iron strut, or *hanger*, is fixed centrally under the beam, or sometimes two are provided, so as to give two points of support. Holes are carefully bored through the beam, and the tie-rod is passed through the perforation and under the hanger, provided with screwed ends, and tightened up with nuts. The depth of the trussing is usually about one-eighth of the length of the beam.

Rain-water Gutters. Almost all roofs that are formed with eaves are supplied with cast-iron gutters, fixed below the bottom course of slates or tiles, to receive the water that comes off the roof and to convey it from the level of the roof to the ground level, or to some receptacle by means of cast-iron pipes. Such gutters are made in a great variety of sections. The simplest is that of a half-round channel [15]; each length is formed with a half socket at one end to receive the end of the next channel, and this and other forms of gutter can be obtained either in straight pieces of various lengths or in the form of short bent channels where it is necessary to carry a pipe round an angle. Where a gutter is required to fit on circular work it very usually has to be specially cast to fit the curve, whereas the bends necessary for many regular angles, such as those of a hexagon or octagon, as well as right angle bends, may usually be obtained from stock.

The end of any length of gutter must be provided with a solid stopped end—that is, one with a vertical end cast in one piece with the gutter. Sometimes attempts are made to close the end of an ordinary channel with a block of wood bedded in red-lead, but such an end cannot be relied on for long.

Where an outlet is required, this is cast solidly with a short length of gutter, and stands below the sole of the gutter for three or four inches, to deliver the water into an open rain-water head [14], or into a rain-water pipe, sometimes called a stack pipe, or down-pipe.

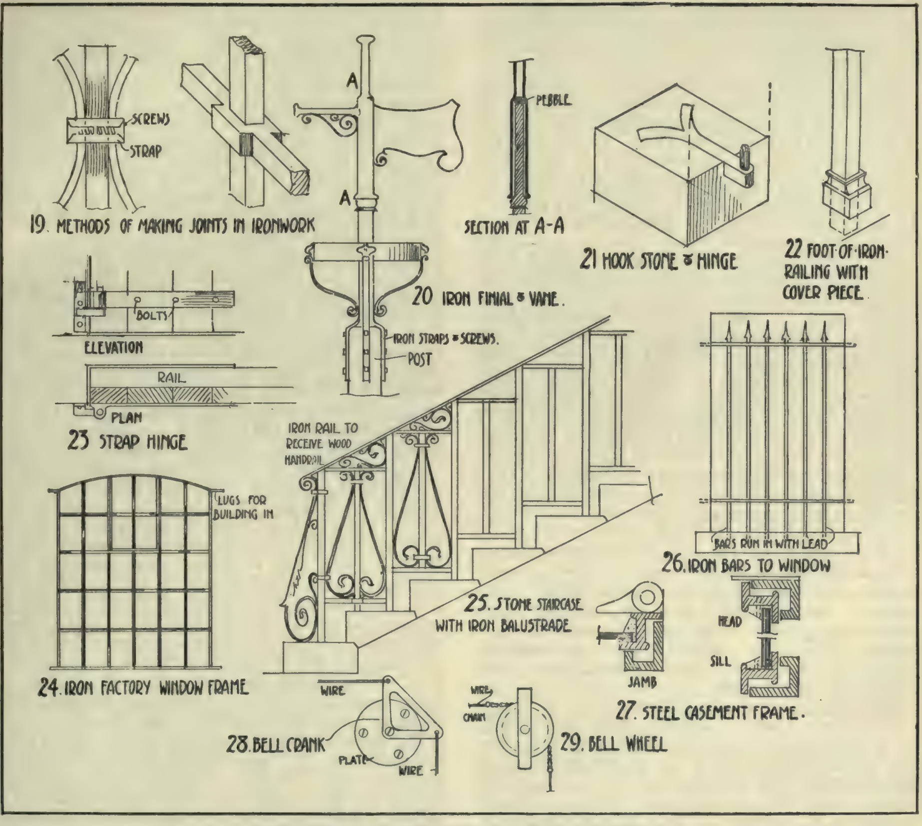
Various Sections of Gutters. Another suitable form of gutter is an ogee moulded gutter, which has a straight back, and the front moulded in ogee form [13]. A great variety of other forms of moulded eaves gutters are made which vary in outline and in size, and which are adapted for use with various styles of architecture. For all such gutters stopped ends, outlets, sockets for jointing, and angle pieces can be obtained. Gutters may also be made to special design where it is preferred, but this requires additional time, as a mould must be made before the gutter can be cast, and the cost is increased by the necessity for these special moulds. Most gutters can be obtained in two or more sizes of the same profile, and many gutters are also cast in at least two weights, *heavy* and *extra heavy*.

Rain-water Heads. Rain-water heads [14] are usually designed to be somewhat ornamental in character. The upper end is of considerable area, so that, if necessary, two or more pipes may discharge into it, while the outlet is contracted to the size of the rain-water pipe above which it is placed. The plan of such a head may be semi-circular, rectangular, or polygonal, and the surface is usually moulded, and sometimes enriched.

Rain-water Pipes. The pipes that convey the water down from the head or gutter to the water-butt or gully may be either circular or rectangular on plan, and may be obtained in various sizes in both forms, and either plain or enriched. The upper end of each pipe is provided with a socket to receive the spigot end of the pipe above, and two small groups of mouldings are formed, one at the top, the other near the lower edge of the socket. Small pipes have projections cast on each side which are termed *ears*, and are used for fixing the pipes to the wall face by means of spikes, much as tacks are used on lead pipes. Larger pipes are usually provided with *loose ears*, which fit round the socket between the upper and lower band of mouldings; these are often of a very ornamental character, as are also the heads of the spikes used for fixing them.

Where a projection occurs in a wall it must either be interrupted to permit of the pipe passing, or the pipe is provided with a *bend* so as to take it past the moulding. This should be made with an easy bend [16]; such a bend is also useful where a vertical pipe has to pass in front of a horizontal one. If there is an offset on the wall, an *offset* must be provided for the pipe, and at the foot of the pipe there is very usually a projecting *shoe* [14], to deliver the water clear of the walls; the pipe may discharge over an open gully trap, and this plan is generally adopted with square pipes, or, if round, it may be connected up with a back or side inlet of a gully.

Various bends are required occasionally in pipes, though it is desirable to run them in as nearly true vertical lines as possible. Many of these bends,



STRUCTURAL IRONWORK AND BELL FITTINGS

offsets, and shoes are kept in stock, but some of them have usually to be specially manufactured.

Fixing Gutters. The joints between successive lengths are usually made in red-lead, and the joint is secured with small bolts and nuts [**17**]. There are various ways of securing the gutter in its proper position, and in doing this it is desirable to arrange that the gutters shall not be fixed in a truly horizontal position, but in an inclined one, so as to secure a slight fall in the sole of the gutter towards the outlet or outlets.

Where the roof is not provided with a fascia, wrought-iron brackets are forged with a twist in them; the lower end of each bracket is shaped to receive the gutter, and the upper end is perforated for screws, by which it is fixed to the side of one of the rafters [**15**]. In this, and in all other positions, where screws are used for fixing such piping, they should be of brass, as these will not rust as iron screws do, and it is of the utmost importance to secure efficiently and permanently the heavy gutters that are often used. This form of bracket is very generally adopted where half-round gutters are used, and readily allows of the necessary adjustment during fixing to supply the fall. Another form of bracket which is adopted for either a round or flat-soled gutter is an adaptation of the form known as a *gallows bracket*, with a vertical back, horizontal top, and inclined stay or brace, or a simple curved bracket [**15**] may be employed. Such brackets are secured to the face of the wall, and may have a distinctly ornamental character given to them. Either of these give a secure and permanent fixing, as they give direct support to the gutter. A very usual method where a fascia board is provided is to secure the gutter to the fascia with strong screws, which should be of brass [**13**]. This is a cheap and easy method of fixing, but the security of the gutter depends wholly on the screws, and if they rust, as iron screws are apt to do, the heavy iron gutter may tear itself away and fall with disastrous results.

Bedding Iron Gutters. One of the safest methods of fixing such a gutter is to bed it solidly in a horizontal projecting course of stone or brickwork [**17**], or on the top of the wall; but this treatment is possible only with certain classes of buildings, and has some drawbacks. These are mainly that it is difficult to give any appreciable fall to the sole of the gutter, and if the outlet becomes blocked, and the gutter overflows, there is a great risk of water finding its way into the heart of the wall, or at least streaming down the face of it instead of falling clear.

Fixing Heads and Pipes. The rain-water head, like the pipes, is provided with ears cast on [**14**]; it is fixed by spikes driven into the wall, or, if it should come against timber framing, by screws, and the outlet in the gutter must be arranged to come over it, and discharge into it. If the pipe receives the discharge only from a single outlet, a head is not essential, but the outlet of the gutter may be connected to

the socket of the top pipe either directly, if it comes vertically over it, or by means of a bent pipe, termed a *swan-neck* [13], if it overhangs the face of the wall considerably.

The rain-water pipe is fixed by spikes in the same way driven through the ears into the joints of the walling. In some cases, to facilitate the painting of such pipes all round, hard wood blocks are fixed in the walls, and the pipes are fixed to these with screws, and stand clear of the walls [14]. Pipes can also be obtained made with a broad hook cast on to the pipe socket, which fits into a special form of socket fixed to the wall face.

In a great deal of work the pipes are merely fitted together, the end of one pipe being dropped into the socket of the next, but the joints are left open. They may, however, be made good with tow and red-lead. Pipes may be obtained with sockets cast on to receive branch pipes from either side [18]; but where another rain-water pipe has to be brought in, or the water from a bath or lavatory, the more usual method is to stop the main pipe, and insert a head to receive the water from the upper pipe, and also that from any additional pipes discharging into the head.

Protecting Outlets and Pipes. It is important to protect both the gutter outlets and the heads, as far as possible, from the risk of leaves collecting or of birds building nests, which would block the outlets; in the case of gutter outlets this is done by placing a dome of galvanised iron or copper wire over the outlet [31 page 5627]; this dome is provided with three or four long, projecting ends which fit into the outlet and keep it in position, as it is not desirable to fix it permanently. Rain-water heads are best covered over with small mesh wire covers.

The method of jointing heavy iron soil pipes has already been described [see page 5030]. It is necessary for the protection of the iron that the surfaces should be protected by paint [see Painting], and that in the case of heads and gutters both the internal and external surfaces should be so protected. This is not possible in the case of the pipes, as their diameter is too small to allow of access to the interior, but such pipes may be protected by dipping them after heating into Dr. Angus Smith's solution [see pages 737 and 5320], which forms a protective coat both inside and out. This gives the pipe a somewhat ugly appearance, as it is nearly black and will not readily take paint, but may be made to do so if a coat of knotting [see Painting] is first applied.

Ornamental Ironwork. Ornamental ironwork is employed for many purposes. It is sometimes added purely as an ornamental feature; in other cases some necessary object is given an ornamental character where its position is prominent. It is not possible to describe fully the infinite variety of uses and forms in which such ironwork may be utilised, and however elaborate the work may be in design, the details of its construction are in most cases really simple. The various elements of any design in wrought ironwork are first forged by the smith into the required shape; these may be formed from lengths of square, flat, or round iron, and may be merely bent to various shapes, or may, in addition, be flattened out and formed into scrolls, or may be hammered out into leaves and other decorative forms. The various members that make up a complete design may be united to each other by being welded together, or may be secured by bands of iron fastened round two or more pieces [19], or by means of short screws for which threaded sockets are formed in the ironwork, or a bar may be passed through a socket in a rail prepared for it.

When the work is of a delicate character it must be strengthened by some form of framed iron which will bind the whole together and afford the means of fixing it. In the case of an ornamental panel this may consist of an enclosing frame within which the more delicate work is contained and which can itself be attached to the surrounding material, whether it be of stone, brick, terra cotta or wood. In other cases strong standards or rails may be provided at intervals to impart stiffness and the means of fixing.

Iron Finials. As examples of ironwork employed for purely ornamental purposes the wrought iron finials that are frequently used to terminate the ridge of a roof or the apex of a turret may be mentioned; these are designed to give a finish to the roof, and in most cases have no other object. They may be comparatively simple or extremely elaborate, depending on the character of the building, and one at least may be treated as a weather vane [20]. They are prepared by the smith and are fixed to a post framed to the ridge and carried down in the roof for some distance, and the lower end secured. The post has a hole bored through it; this extends from the top to the bottom if it is a short post, or if long, for a length of, say, 6 ft. to 10 ft.; the finial has an iron rod extending below the base, and this is passed down through the perforation and secured with a nut at the lower end. Straps are also provided, three or four in number, but much shorter, and these extend down the outside of the post and are fastened to it by screws or by one or more iron bands encircling the post. Such finials may form isolated objects or may be connected with a continuous wrought iron cresting, where the roof has a long ridge.

For the most part, however, wrought iron is used in connection with building, for purposes in which utility is the primary reason for its selection; the facility with which it can be manipulated by a skilled craftsman, and the permanent character of the work if properly protected from the action of the weather, render such work eminently suitable for ornamental treatment.

Iron Grilles. One very usual example of such use of ironwork is the use of protecting screens or grilles. These may be required to be very strong and heavy in the case of external window openings, or they may be comparatively slight, for instance, in the case of a lift enclosure; but in both cases it is quite possible and usual to make such necessary objects ornamental. On the other hand, they may be perfectly plain and purely utilitarian in character. The simplest form of protection to an external window is arrived at by providing a series of square or round iron bars set vertically so close together that it is impossible for even a boy to pass between them [26]. If the opening has a stone sill, the lower end of each bar may be let into the sill, but the other end must be passed through a flat iron bar fixed to the jamb of the opening, and in many cases the lower end is fixed in the same way, and if the opening is tall, intermediate bars are required to stiffen the uprights. Such a frame as described answers every requirement so far as utility is concerned, but can in no sense be considered ornamental; but a comparatively small amount of additional labour may convert it into an object of beauty. The ends of the vertical bars may be bent and forged into ornamental forms; the bars themselves may be twisted and the horizontal bars notched, and other purely ornamental features may be added,

Fixing Ironwork to Stone and Brick. There are various methods of fixing such a grille into the surrounding materials, depending on the nature of the material in which the iron is fixed and its position. In the case of stonework, a mortise is cut into the stone and the end of the bar or rail is inserted into it. If a rail has to be fixed between two jambs, one of the mortises must be cut deep enough to allow of the rail, which is, say, 2 in. wider than the opening, being passed into it far enough to allow of the other end being introduced between the jambs and then inserted in its mortise. For work not exposed to weather, the mortise may be run in with molten lead, but for external work cement is better. Where the ends of rails are let into brick jambs, mortises must be prepared and the ends of the rails made fast to them in cement. Where such protection is required to be fixed to wood frames the ends of the rails may be turned up or down and perforated and countersunk for screws.

The method of fixing iron grilles in window openings applies to a great deal of other ironwork used in connection with building operations, such as enclosing rails to areas and similar positions let into stone copings and the newels and balusters of plain or ornamental iron balustrades to stone staircases [**25**]. In the case of objects of a highly ornamental character that come near the level of the eye and in which the method of fixing would be unsightly this may be concealed by the use of a separate base, ornamental in character, with a perforation in the centre so that it will slide up the standard for a short distance during the operation of fixing and may be afterwards returned to the bottom so as to cover the leadwork [**22**].

Strap Hinges and Pivots. The pivots for the strap hinges of heavy gates and doors, where they are hung direct to brick or stone jambs without any wood frame, are usually secured to blocks of stone, termed *hook stones*. The pivots are formed with long, rough fangs of iron behind the carefully finished pin, and the surface of the stone has sinkings cut in it to receive these [**21**]; after they are in position they are run with lead, which fixes the ironwork in the stone, and the latter may afterwards be built into the wall leaving the pin projecting. The hinges themselves are usually of the form known as *strap hinges*, in which a broad plate of iron of considerable length is carried across the door on one face and sometimes on both, and bolted to it with short bolts passing through both the hinge and the framing of the door [**23**]. These hinges may be of an exceedingly ornamental character, with hammered scrolls and other ornamental work extending both above and below the strap itself and in some cases designed to extend over a large portion of the surface of the door.

Various Work in Wrought Iron. The uses of wrought iron in connection with building are numerous, and space will not allow of a full description of them, but a few may be briefly referred to, and those selected will be mainly those which have to be specially prepared for their situations. Iron ties are sometimes required for sustaining the walls of a house showing signs of failure. They are long rods, which are passed through from side to side of the house, generally at a floor level, and have plates fixed outside the walls, through which the rods are passed. At one end the rod is perforated, and a steel key passed through to provide a bearing; the other end is tapped, and has a nut.

Chimney bars are short tie bars to prevent the jambs of a fireplace being thrust out by the arch, and are cambered, or bent, so as to form a centre for the arch; the ends are split and turned up and down for building in to the brickwork. There are many other fittings that are made of wrought iron by special makers for fixing in buildings such as wrought-iron window casements and frames [**27**], iron doors and frames, jibs and hoists, boilers, cisterns, etc., but it is not possible to describe them in detail, and in most cases when fixing is required they may be secured much as already described for other fittings.

Cast Ironwork. *Cast iron* has its own special uses, but it may be used for many purposes for which wrought iron is better employed. It is chosen on the ground of cheapness, but as it is cast from a mould it is not, from the artistic point of view, so well adapted to work in which there is much repetition as wrought iron. Let us consider, for example, the case of a long length of iron railing where each bay is of the same design as every other. If the railing be of wrought iron, there will be slight differences in the curves and treatment even of a repeating design, due to the labour of different workmen, which will lend variety and beauty to the whole; but if the railing is cast, every bay will issue from the same mould, and will be identical and monotonous. On the other hand, the cast work will be very much less costly than the wrought.

There are, however, many purposes for which cast iron is properly and legitimately used in building work, such as rainwater gutters and pipes, which have been already referred to. Another direction in which cast iron is very largely used is for all kinds of ranges, and it is also very extensively used for many forms of fire stoves and grates, which are made in a great variety of designs, the best of which are not only very serviceable for their purpose, but artistically good.

Staircases, both circular and square in plan, are readily constructed of steps formed of cast iron, and this material is largely employed for various classes of fittings, especially those used in connection with the fitting-up of stables and some sanitary fittings, such as baths and small cisterns.

Objects formed in cast iron which are similar to wrought iron ones are fixed in the same manner to either stone or brick, or to joinery.

Window frames for factory buildings are often formed of cast iron, and are provided with projecting lugs for building into the brick walls, and are subdivided by vertical and horizontal bars [**24**].

Chequer plates and *gratings* of various designs and sizes are formed of cast iron. The latter are used both for covering channels containing hot-water pipes, and for admitting air to buildings through openings formed in the walls. Coal plates and manhole covers are other examples of cast iron used in connection with building, but in almost all these examples the objects are made by special manufacturers and supplied to the builder ready for fixing.

Gasfitting. The work of the gasfitter consists in providing and fixing the pipes which are to connect the gas-meter with the various points throughout a building at which gas will be required, and these points include not only those required for lighting the various rooms and passages, but in many cases the supply of gas to gas fires, cooking stoves, and rings, and, in some cases, to engines.

The cost of the piping used in gasfitting is not very heavy, and it is advantageous to have the pipes amply large; there is always moisture present with gas, and corrosion takes place on the inside of the pipe, with the result that the bore

becomes reduced, and if, in the first place, it is only just adequate, the supply of gas is likely to become deficient. It also frequently happens that after the original fitting-up of a house is complete, a few additional points may be added from time to time to supply a ring or fire, and this is greatly facilitated if pipes are amply large.

Capacity of Pipes. The number of lights that may be properly supplied by any pipe may be estimated as follows. Take the diameter of the bore—that is, the internal diameter of the pipe—in eighths of an inch, square the number, and if the length of the pipe is under 60 ft., divide the result by 2, or if over 60 ft., by 3; this will give the number of lights. *Example:* A $\frac{3}{4}$-in. pipe has a diameter of six-eighths, $6^2 = 36$, $\frac{36}{2} = 18$ lights, or $\frac{36}{3} = 12$ lights. In the case of gas fires, cooking apparatus, gas engines, etc., the size of the pipe required must be ascertained from the manufacturers.

Meters for registering the amount of gas used are generally hired from the company supplying the gas; they may be bought by the consumer and fixed as his property, but for domestic supplies the more usual course is to hire the meter. This is fixed inside the building at a point as close to the company's main as possible, and no branch of any kind must be taken from the pipe between the main and the meter. It should be fixed at some point where it is convenient for access, as the register on the front of the meter must be read quarterly by the inspector; a coal-cellar, though not infrequently used, is a most unsuitable place. Meters are of two kinds—dry and wet—and they are capable of supplying a considerably larger number of lights than their nominal capacity, which may be from 1 light up to 1,000 lights.

Connecting to the Company's Main. This connection is made by the company's own workmen, but the ground is opened and the cost of the connection is borne by the builder or proprietor. An iron screw ferrule is used, and wrought-iron welded gas tubing is taken from the main to the building, and should be buried at least 2 ft. deep. At a convenient point outside the premises a fullway brass stopcock is fixed in the run of pipe in an iron chamber bedded on concrete, and if the pipe descends from the main to the building, a *syphon box* must be inserted on the house side of the stopcock. This is also fixed below the ground level, and is required for collecting any condensed liquids that may enter the pipe from the mains. In many installations a self-acting *governor* is introduced. This regulates the pressure of the gas, which is apt to vary considerably in the mains at different times, and prevents gas passing through the meter at a pressure which will prevent its proper combustion, and thus allow of waste. Where a large amount of gas is burnt, the use of a governor may result in considerable economy. The connection to the meter is made with a heavy lead pipe, and this is connected to the iron pipe with a brass union. The outlet from the meter has also a heavy lead pipe, and a fullway brass stopcock, and brass union to the service pipe to the building. The size of the pipe both to the inlet and outlet is regulated by the size of the meter.

The Service Pipes. In all work of an even moderately good quality, the pipes for conveying gas are made of wrought iron welded tubing, with screwed connections and with elbows, bends, tees, nipples, reducing sockets, caps, and plugs for introducing where required. The usual sizes of pipes are $\frac{1}{4}$ in., $\frac{3}{8}$ in., $\frac{1}{2}$ in., $\frac{3}{4}$ in., 1 in., $1\frac{1}{4}$ in., $1\frac{1}{2}$ in., $1\frac{3}{4}$ in., 2 in., $2\frac{1}{4}$ in., $2\frac{1}{2}$ in., $2\frac{3}{4}$ in., and 3 in., and the various details above referred to are made to correspond.

Composition pipes are also made of the following sizes—$\frac{1}{4}$ in., $\frac{5}{16}$ in., $\frac{3}{8}$ in., $\frac{7}{16}$ in., $\frac{1}{2}$ in., $\frac{5}{8}$ in., $\frac{3}{4}$ in. $\frac{7}{8}$ in., and 1 in., but they are used only for inferior work, and are a source of danger in a house. They are usually buried in the plaster of the wall, and are easily damaged; for example, in hanging pictures nails may very easily be driven into them, leading to an escape of gas, and when carried in partitions or under floors, they may sometimes be attacked by rats with a similar result, and in such a case the source of leakage may be very difficult to detect. In the event of fire they are also liable to melt and allow an escape of gas, which may ignite.

Running Services. The presence of moisture in gas has already been referred to, and this is a matter that affects the method of distribution in an important manner. The moisture is apt to condense inside the pipes, and unless it can pass out of the pipe water may gradually accumulate, and if at any point the pipe has a dip in it, it will collect in the lowest part and may partially or wholly block the pipe. This interferes with the passage of gas, and may lead to the light *jumping*; this occurs when the obstruction is sufficient to check the gas to such an extent that considerable pressure is created behind the block. When this reaches a certain point it drives the water before it, and the gas passes on to the burner, which for a short while burns brightly; but the water returns, creates a fresh obstruction, and the light becomes dim, and this alternation continues at regular intervals till the water is withdrawn.

All pipes, therefore, should, wherever possible, be laid so that there is no dip at any point, and it is desirable that in horizontal pipes there should be a slight uniform fall towards the vertical pipe from which the branch is taken, and thence towards the meter. This plan cannot be always observed, but if a pipe is bound to descend for some distance and then rise again, thus forming a dip, an outlet should be provided at the lowest point with a draw-off tap, so that the water, if it accumulates, can be drawn off. This tap should be fitted with a loose handle so that it cannot be tampered with. Where wall brackets are employed the supply pipe should, whenever possible, be brought up to them from the floor level, not down to them from the ceiling level.

Branch Services. In many buildings it is convenient to divide the main service pipe very soon after it leaves the meter, and to arrange for the lighting of different sections of a building by independent services; when this is done it is convenient to provide each main service with a stopcock so that it can be shut off when required.

The gasfitter usually runs his pipes before the walls are plastered; care must be taken to see that at all points to which fittings are afterwards to be attached, screw plugs are inserted in the open ends of the pipes; otherwise the plasterer is certain to choke them wholly or partly with his materials.

Fixing Pipes. The pipes are usually fixed with wall hooks against brick walls, and with iron or brass bands to woodwork. From many points of view it is advantageous to allow gaspipes as well as waterpipes to be fixed on the finished surface of the plaster, as it facilitates the detection of any escape; but the pipes with their screwed joints are somewhat unsightly even if painted. They may, however, be covered by a small pipe casing fixed with screws for easy removal. In fixing the position of points to which fittings are to be attached, careful

consideration must be given to the use that is to be made of the room and, where possible, to the probable arrangement of the furniture. No gas bracket should be fixed so close under a ceiling that it is likely to be a source of danger of fire, and any bracket fixed nearer than 3 ft. below a ceiling or other woodwork should be fixed so that it cannot swing sideways, and should be protected by a brass or metal bell suspended over it.

Gas Fittings. Gas fittings are not included in most building contracts. The usual fittings are divided into two main classes—*pendant fittings*, which are suspended from the ceiling, and *wall brackets*, which are fixed against the wall. They are usually attached to the pipes by screw joints, but are provided with a flange which may be screwed to wood bosses fixed to either the ceiling or wall. Pendants may be either fixed or provided with a ball and socket joint so that they can be moved to one side and rotated if necessary; they may be fitted with a single light or with any larger number required, and are manufactured in an almost infinite variety of design and price.

Brackets are also attached by screwed joints to the pipe, and by means of flanges to wooden bosses, and are termed *stiff* brackets when they consist of a single arm carrying the burner and are rigidly fixed to the wall, or *single-swing* or *double-swing* brackets when they are movable; the latter are sometimes a source of danger if they are fixed within reach of any inflammable substance, as they may be swung so close to it as to set it on fire. Fixed brackets may be arranged, if necessary, for two or more lights, and, like pendants, are made in a great variety of designs and vary much in cost.

Many brackets and pendants are provided with a nozzle fitted with a tap to which a standard gas lamp or a small gas ring or similar apparatus may be attached by means of a flexible indiarubber or metal tube provided with a screw attachment at both ends, one of which fits in to the nozzle and the other to the fitting. Except for such fittings which require only temporary attachment, indiarubber tubing is not used for conveying gas.

Bell Hanging. A few years ago mechanical bells were used exclusively; the introduction of electric and, to a less extent, of pneumatic bells, has to a great extent limited the use of mechanical bells, but they are still employed, and are reliable if well fitted up.

The bell is formed of an alloy of tin and copper, and usually varies in weight from 14 oz. to 32 oz. Where several bells are required they must be arranged of different tones, corresponding with the various rooms from which they ring. Such bells are usually lacquered to prevent corrosion. They may be fitted up with a small pendulum, which will swing when the bell is rung, and continue to swing after the sound has ceased, thus indicating which bell has been pulled. In this system every room that has a bell-pull must have a separate bell to correspond with it; these are generally arranged on a bell board fitted in the kitchen or other convenient place. The bell is hung on one end of a spiral spring, the other end is attached to a bell carriage which is fixed on a pivot to the board, and which allows of a lever being pulled, causing the bell to oscillate and ring.

Bell Fittings. The *bell-pull* is made in various forms; for sitting-rooms it usually consists of a lever handle which, when pressed down, revolves a metal drum to which a short roller chain is attached connected with the wire, and, when released, the handle is returned to its normal position by a spring. A pendant pull is also used; for external doors this may be of wrought iron or similar material; for bed-rooms it usually consists of a hanging cord of worsted or silk, or a slide pull may be formed, which is similar in its action.

A straight pull-out is very commonly fixed to external doors, the handle formed by a knob surrounded by a dished or sunk plate, so that the knob is protected from injury, and can be easily grasped. Between the handle of the pull and the bell on the bell-board it is essential there should be a continuous connection that is not liable to stretch.

Bell wire is usually drawn copper wire from No. 16 to No. 19 B. W. G., and this should be thoroughly stretched before fixing, as it is important that it should not stretch after it is fixed; if the bell is to be efficient the wire must continue perfectly taut throughout its length. It very rarely happens, however, that the wire can be stretched in a straight line between the pull and the bell; where any change of direction is made this must be done by means of a crank or a wheel. The *crank* [28] is a lever working on a pivot, and is generally cast in brass, with two arms at different angles corresponding with the direction of the two wires. In common work wires are run on the surface, a series of staples are fixed to the wall, through which they are passed; but in better work they are run in tubes of galvanised iron, brass, or copper buried in the walls. Zinc is not suitable for such tubing as, if any moisture is present, a galvanic action may be set up between the two metals; the mouth of the tube may be lightly enlarged into a trumpet form to prevent any chafing of the wire.

The Wheel and Chain. The drawback to the crank is that the end of either arm, when the bell is pulled, does not move in a straight line, but in the arc of a circle, and the end of the wire attached to it, though it moves in the main laterally, has also a slight vertical movement; to avoid this a *wheel and chain* [29] is substituted in good work. The wheels are of brass, with a grooved edge, mounted in a brass frame, and a short length of flexible brass chain is employed, to which the two wires are attached; the advantages of this system are that the pull is always in the same direction, and that the wheel allows of the wires being run at either an acute or obtuse angle to each other more readily than does the crank.

Where bell wires have to be run under floors the boards over them should be fixed with screws, so as to allow of easy removal for repairs.

Fitting up bells is a process that requires considerable care, as the efficiency of the bell depends on the wire being perfectly taut, and being maintained in that condition. If the wires become slack, the bell is not acted upon when the pull is moved unless it is very violently jerked, and this is liable to snap the wire.

The cranks or wheels are fixed with screws to any convenient joinery or to plugs driven into brick walls, and must be arranged so that when the wire is taut it will pass straight through the intermediate tubing without rubbing against the sides. The wires are passed through eyes formed in the angles of the cranks, and the end is returned and neatly whipped round the wire, making it fast; in the case of chains, similar eyes are provided. Where several bells are fitted on one board care must be taken to see that they in no way interfere with each other.

Continued

FRENCH—SPANISH—ESPERANTO—GREEK

French by Louis A. Barbe, B.A.; Spanish by Amalia de Alberti and H. S. Duncan; Esperanto by Harald Clegg; Greek by G. K. Hibbert, M.A.

FRENCH

Continued from page 5654

By Louis A. Barbé, B.A.

PRONOUNS

Personal Pronouns—continued

11. It is important to distinguish between *leur* as a personal pronoun and *leur* as a possessive adjective. As a pronoun, *leur* is both masculine and feminine, and never takes *s*. It is mainly, but not exclusively, used with reference to persons: *Malgré l'ingratitude des hommes, il ne faut pas se décourager de leur faire du bien,* In spite of the ingratitude of men, we must not grow weary (discouraged) of doing them good; *Ces plantes vont périr si vous ne leur donnez de l'eau,* Those plants will die if you do not give them water.

12. The pronoun *le* is variable when it stands for a noun or for an adjective used substantively: *Je me regarde comme la mère de cet enfant; je la suis par ma tendresse pour lui,* I look upon myself as the mother of that child; I am so by my affection for him.

13. The pronoun *le* is invariable when it stands for (*a*) an adjective, (*b*) a noun used adjectively, (*c*) an infinitive, or (*d*) a whole clause:

(*a*) *Cette femme est belle, mais elle ne le sera pas toujours,* That woman is good-looking, but she will not always be so;

(*b*) *Ceux qui sont amis de tout le monde ne le sont de personne,* Those who are friends (friendly) with everybody are so with nobody;

(*c*) *Ces hommes font bien de se cacher; ils doivent le faire,* These men do well to keep themselves retired (lit. to hide themselves); they must do so.

(*d*) *Si le public a eu quelque indulgence pour moi, je le dois à votre protection,* If the public has had some indulgence for me, I owe it to your protection.

14. *Le, la, les,* may be placed between the pronoun *ce* and the verb *être* if they refer to inanimate objects and are not followed by a relative clause: *Est-ce là votre grammaire? Oui, ce l'est,* Is that your grammar? Yes, it is; *Sont-ce vos maisons? Oui, ce les sont,* Are those your houses? Yes, they are.

15. When the pronoun refers to persons, or is followed by a relative clause, it is better to use *lui, eux, elle, elles*: *Sont-ce vos amis? Oui, ce sont eux,* Are those your friends? Yes, they are; *Est-ce là votre maison? Oui, c'est elle qu'on aperçoit parmi les arbres,* Is that your house? Yes, that is it which you perceive among the trees.

16. *Soi* is both masculine and feminine, but always singular. When used of persons, it can only refer to an indefinite subject, such as *on, chacun, quiconque, personne, tout le monde, tout homme,* etc: *On a souvent besoin d'un plus petit que soi,* One often has need of one smaller than oneself; *Chacun pour soi,* each for himself. But we must say: *Cet homme ne parle que de lui,* That man speaks about himself alone.

17. When *soi* is used of inanimate objects, it may refer to a definite subject: *La vertu est aimable en soi,* Virtue is lovable in itself.

18. When several verbs having the same pronoun as subject are not joined by a conjunction, that pronoun may be either repeated before each of them or used before the first of them only: *Tu aimeras tes ennemis, tu béniras ceux qui te maudissent,* Thou shalt love thy enemies, thou shalt bless those that curse thee; *Livré à son désespoir, il s'arrache les cheveux, se roule sur le sable, appelle en vain à son secours la cruelle mort,* Abandoned to his despair, he tears his hair, rolls on the sand, vainly calls cruel death to his help.

19. When verbs having the same pronoun as subject are joined by one of the conjunctions *et, ou, mais, ni,* the repetition of the subject is optional and a matter of style: *Nous avons dit et nous allons prouver qu'il n'y a pas de bonheur sans la vertu,* We have said, and we are going to prove, that there is no happiness without virtue.

20. When verbs having the same pronoun as subject are joined by any conjunction except *et, ou, mais, ni,* that subject must be repeated: *Vous serez vraiment estimés, si vous êtes sages et modestes,* You will be really esteemed if you are wise and modest.

21. When, of two verbs having the same pronoun as subject, the first is affirmative and the second negative, the repetition of the pronoun is optional: *Je plie et ne romps pas* (*Je plie et je ne romps pas*), I bend and do not break.

22. When of two verbs having the same pronoun as subject, the first is negative and the second affirmative, that pronoun must be used before each verb: *Je ne romps pas, mais je plie,* I do not break, but I bend.

23. When several verbs have the same pronoun as their object, that pronoun must be repeated if the verbs are in a simple tense: *Les morts et les vivants se succèdent et se remplacent continuellement,* The dead and the living continually succeed and replace each other.

24. If the verbs which have a pronoun for their common object are in a compound tense, that object does not require to be repeated. In that case, however, the auxiliary is also omitted: *Ils nous ont rencontrés et salués,* They met and bowed to us.

25. If the pronoun which is the common object of two or more verbs is not governed in the same case by each of them, it must be repeated: *Ils nous ont rencontrés et nous ont parlé,* They met us and spoke to us.

II. Demonstrative Pronouns

1. What is known as the pleonastic use of *ce*—that is, the use of *ce* when the sense of the sentence does not require it, and when, indeed, it has no equivalent in the English sentence—is subject to the following rules:

(*a*) When the nouns which are respectively the subject and the attribute of some tense of the verb *être* can change places without materially affecting the sense of the sentence, the verb may take *ce* before it, and very generally does so: *La vraie noblesse, c'est la vertu* (*La vraie noblesse est la vertu*), True nobility is virtue.

(*b*) When both the subject and the attribute of *être* are infinitives, the verb must be preceded by *ce : Travailler c'est prier,* To work is to pray.

(*c*) If the verb is negative, the use of *ce* before it is not necessary ; *Brûler n'est pas répondre,* Burning is not answering.

(*d*) The negative verb may begin the sentence. In that case it must be preceded by *ce*, and the second infinitive takes either *que de,* or *que* alone before it : *Ce n'est pas répondre que de brûler.*

(*e*) *Ce* is not used before *être* if its subject only is an infinitive : *Bien écouter est une des plus grandes qualités de la conversation,* To listen well is one of the greatest qualities of conversation.

(*f*) When a sentence begins with *ce qui, ce que,* or *ce dont,* the verb *être* takes *ce* before it if it is followed by a noun or by an infinitive : *Ce qui m'indigne le plus, c'est l'injustice des hommes,* What makes me most indignant is the injustice of men.

(*f*) When in a sentence beginning with *ce qui, ce que,* or *ce dont,* the verb *être* is followed by an adjective, it does not take *ce* before it : *Ce que vous nous dites là est absurde,* What you are telling us is absurd.

2. In English, the relative pronoun may have a whole clause for its antecedent ; in French the relative must be preceded by *ce* : *Il trouvait sa bonne ménagère qui lui souriait à travers les vapeurs du repas du soir, ce qui lui réjouissait fort le cœur,* He used to find his good housewife, who smiled at him through the fumes of the evening meal, which greatly delighted his heart.

3. In English, "all" may immediately precede a relative pronoun. In French, *ce* must be placed between them : *Tout ce qu'il voyait lui semblait admirable,* All that he saw seemed to him (to be) admirable.

4. If "all" refers to several persons or objects, *ceux* or *celles* must be used between it and the relative : *Il est respecté de tous ceux qui le connaissent,* He is respected by all who know him.

5. The demonstrative pronouns *celui, celle, ceux, celles,* may not immediately precede an adjective or a participle, as is frequently the case in English. It is, consequently, incorrect to say : *Les nombres ordinaux se forment des cardinaux ; dans ceux terminés en* f, *on change* f *en vième.* The proper construction is : *Les nombres ordinaux se forment des cardinaux ; dans ceux qui sont terminés en* f, *on change* f *en vième,* The ordinal numbers are formed from the cardinal ; in those which end in *f*, *f* is changed into *vième.*

6. When referring to persons or objects previously mentioned, *celui-là, celle-là, ceux-là, celles-là,* indicate the former, whilst *celui-ci, celle-ci, ceux-ci, celles-ci* indicate the latter : *On disait de Fénelon en le comparant à Bossuet, que celui-ci prouvait la religion et que celui-là la faisait aimer,* It was said of Fénelon, in comparing him with Bossuet, that the latter proved religion, and that the former caused it to be loved.

7. *Ceci* is used to indicate a statement that is going to be made, and *cela* a statement that has just been made : *Retenez bien ceci ; il faut être juste envers tout le monde,* Bear this well in mind : you must be just to everybody. *Il faut aimer son prochain comme soi même ; n'oubliez jamais cela,* You must love your neighbour as yourself ; never forget that.

8. Colloquially and familiarly, *cela* is contracted into *ça* : *Quand même il n'y gagnerait que cinq francs, c'est toujours ça,* Even though he should earn only five francs at it, it's always that much.

9. In familiar language, *cela* (*ça*) is sometimes applied to persons : *Regardez ces enfants ; cela est heureux ; cela ne fait que jouer,* Look at those children ; they are happy ; they do nothing but play.

10. When *cela* is the subject of *être* it is sometimes divided into two words, *ce* coming before the verb, and *là* (with the grave accent) after it : *C'est là une bien rude tâche que vous entreprenez,* That is a very difficult task you are undertaking.

11. Adjectives used attributively in connection with *ceci* and *cela* take the preposition *de* before them : *C'est un discours qui a ceci de bon ; il n'est pas long,* It is a speech that has this good (about it) ; it is not long.

III. Relative Pronouns

1. The relative pronoun should be as near its antecedent as possible. The neglect of this rule produces ambiguity, and sometimes nonsense. The absurdity is obvious in : *J'apporte des joujoux pour mes enfants qui sont dans ma poche.* It must be avoided by saying : *J'apporte pour mes enfants des joujoux qui sont dans ma poche,* I have brought for my children some toys that are in my pocket.

2. Sometimes it is not possible to avoid ambiguity by bringing the antecedent and the relative close together. In that case the ambiguity is removed by using *lequel, laquelle, duquel, de laquelle,* instead of *qui, que, dont* : *Tous les voyageurs ont parlé de la fertilité de ce pays, laquelle est véritablement extraordinaire,* All travellers have spoken of the fertility of that country, which is really extraordinary.

3. Sometimes ambiguity is avoided by putting the conjunction *et* between the relative and a noun, and thus indicating that this particular noun is not intended to be the antecedent of the relative : *Nos soldats, acharnés à la poursuite des ennemis, et qui ne connaissaient pas la disposition du terrain, se trouvèrent bientôt séparés les uns des autres par les marais et les fondrières,* Our soldiers (who were) doggedly intent on the pursuit of the enemy, and who did not know the lie of the land, soon found themselves separated from each other by the marshes and the quagmires.

4. If the antecedent of a relative pronoun is a noun, or a personal pronoun preceded by a preposition, that preposition must not be repeated before the relative. It is therefore incorrect to say : *C'est à lui à qui je parle.* The relative must be replaced by the conjunction *que* : *C'est à lui que je parle,* It is to him that I am speaking. It is permissible, however, to omit the preposition before the antecedent, and to place it before the relative : *C'est lui à qui je parle,* It is he to whom I am speaking ; *C'est mon père dont il parle,* It is my father he is talking about.

5. If the antecedent of the relative is a personal pronoun in the conjunctive form, that pronoun must be repeated in the disjunctive form before the relative : *Il était inutile de lui parler, à lui qui ne comprenait pas le français,* It was useless speaking to him, who did not understand French.

6. *Qui* has neither gender, number, nor person of its own, but it communicates the number and person of its antecedent to the verb of which it is the subject, and the gender and number of that antecedent to adjectives or participles in agreement with it : *C'est moi qui suis chargé de vous conduire,* It is I who am commissioned to conduct you.

7. There is a construction in which a noun is joined by *comme* to the personal pronoun immediately preceding *qui.* In that case the noun, not the

personal pronoun, is the antecedent, and the agreement is with that noun : *Ce n'est pas un homme comme vous qui se permettrait d'employer de telles paroles,* It is not a man like yourself who would allow himself to use such words.

8. *Qui* with a finite tense is frequently used in French instead of the English present participle : *Le voilà qui vient là-bas,* There he is coming yonder.

9. *Qui* preceded by a preposition refers to persons only. After a preposition, the relative referring to animals or inanimate objects must be *lequel, laquelle,* etc. : *Il faut bien choisir les personnes à qui on donne sa confiance,* We should carefully choose the persons on whom we bestow our confidence; *C'est une condition sans laquelle je ne consentirai à rien,* It is a condition without which I will not consent to anything.

10. Sometimes, when the antecedent is vague and indefinite, such as *ce, voilà, rien,* the relative *quoi* is used instead of *lequel,* etc., after a preposition : *Il n'y a rien sur quoi on ait plus écrit,* There is nothing about which more has been written.

11. The expression *de quoi* is used to indicate means, cause, sufficiency : *Il n'est pas riche, mais il a de quoi vivre,* He is not rich, but he has enough to live on.

12. *Dont* is used for both masculine and feminine, singular and plural. It may refer to persons or things: *C'est un homme dont le mérite égale la naissance,* He is a man whose merit equals his birth ; *Il n'y a point de mal dont il ne naisse un bien,* There is no evil from which there does not spring some good; *Voilà des livres dont la lecture vous intéressera,* There are some books of which the reading will interest you.

13. *Dont* cannot be preceded by a preposition. When there is a preposition, the relative must be either *de qui,* or *duquel, de laquelle,* etc., for persons, and *duquel, de laquelle,* etc., alone, for things : *C'est un guide à l'expérience de qui vous pouvez toujours vous fier,* He is a guide to whose experience you can always trust ; *Remerciez l'ami au dévouement duquel vous devez la liberté,* Thank the friend to whose devotedness you owe your liberty ; *Il y avait là quelques arbres sous le feuillage desquels nous nous mîmes à l'abri,* There were there a few trees, beneath the foliage of which we sheltered ourselves.

14. In expressions referring to extraction, origin, etc., *dont* has a figurative meaning. The literal meaning is expressed by *d'où* : *La maison dont il sort,* The house (family) from which he comes; *La maison d'où il sort,* The house out of which he comes.

15. In English, the noun following *whose* is never accompanied by the article. In French, the noun after *dont* always takes the article : *C'est un écrivain dont les œuvres sont connues de tout le monde,* He is a writer whose works are known by everybody.

16. In English, the noun following *whose* may be either the subject or the object of the relative clause. In French, only the subject of the relative clause can come immediately after the verb : *Je plains les laboureurs dont les champs ont été dévastés par l'inondation,* I pity the husbandmen whose fields have been devastated by the inundation; *Je plains les laboureurs dont l'inondation a dévasté les champs,* I pity the husbandmen whose fields the inundation has devastated.

17. The relative pronoun may never be omitted in French, as it frequently is in English : *Je viens de recevoir une lettre de la dame que nous avons rencontrée la semaine dernière,* I have just received a letter from the lady we met last week.

18. The English construction which consists in putting a preposition at the end of a relative clause, with or without the relative, is inadmissible in French : *Voilà le monsieur avec qui nous sommes venus de Londres,* There is the gentleman whom we came from London with (with whom we came from London); *Ce sont les amis dont je vous ai parlé,* They are the friends I spoke to you about.

IV. Indefinite Pronouns

1. *Autrui* is never used as the subject of a verb, and very seldom without a preposition before it. It is more vague and general in its meaning than *autres* : *Attendez d'autrui ce que vous faites à autrui,* Expect from others what you do to others.

2. *Chacun* may have either *son, sa, ses,* or *leur, leurs* for its corresponding possessive :

(*a*) When *chacun* is the subject of the verb, possession is expressed by *son, sa, ses* : *Chacun doit corriger le devoir de son voisin,* Each one must correct his neighbour's exercise.

(*b*) *Chacun* is followed by *son, sa, ses,* when it comes after the object of the verb and is not necessary to complete the sense of the sentence : *Ils ont donné leur avis, chacun selon ses vues,* They have given their advice, each according to his views.

(*c*) When *chacun* is placed before the direct object of the verb it takes *leur, leurs* as its possessive : *Ces deux généraux ont chacun leur mérite,* Those two generals have each their merit; *Les abeilles bâtissent chacune leur cellule,* Bees build each their own cell; *Les langues ont chacune leur bizarreries,* Languages have each their own peculiarities.

(*d*) When the verb is in the first or second person plural, the possessives corresponding with *chacun* are, respectively, *notre, nos,* and *votre, vos* : *Nous devons secourir les malheureux chacun selon nos moyens,* We should help the needy, each according to our means.

(*e*) The reflexive pronoun corresponding with *chacune* is *se, soi ; Chacun pour soi,* each one for himself.

3. *Personne,* meaning somebody, anybody, is always masculine. In connection with *ne,* it means nobody : *Nous avons attendu deux heures, mais personne n'est venu,* We waited two hours, but nobody came.

4. *Quelqu'un,* meaning somebody, anybody, is always masculine : *Quelqu'un a-t-il jamais douté sérieusement de l'existence de Dieu ?* Has anybody ever seriously doubted the existence of God ?

It is sometimes used in the plural with the meaning of some, a few : *Quelques-uns croient tout le contraire,* Some believe the very opposite.

5. *Quelque chose,* meaning something, anything, is masculine, though formed from the feminine noun *chose* : *Si l'on vous offre quelque chose, ne le refusez pas,* If you are offered anything, do not refuse it.

This is to be distinguished from *quelque chose que,* whatever, in which *chose* is a noun, and consequently feminine : *Quelque chose qu'il ait faite, vous ne devez pas vous en étonner,* Whatever he has done, you cannot be surprised at it.

6. *Quiconque,* whoever, is masculine, and has no plural : *Quiconque n'observera pas cette loi sera puni,* Whoever does not observe this law shall be punished.

NOTE. The indefinite personal pronoun *on* has already been dealt with as a personal pronoun.

Continued

SPANISH Continued from page 5516 By Amalia de Alberti & H. S. Duncan

GENERAL CORRESPONDENCE

Modes of Address

The chief point to be remembered is that *Don* and *Doña* must always be followed by a Christian name, while *Señor* and *Señora*, which are used with the surname, precede *Don* in formal address. Full formal address is *Señor Don Pedro de Ayala.*

In introducing one person to another, and in speaking of him, use *El Señor de Ayala;* and in direct address, *Señor de Ayala.*

On slight acquaintance, *Don Pedro* would be permissible, both from men and women. It is also quite correct in Spain for a lady to address a gentleman by his surname, without any prefix, if they are great friends. In such a case, therefore, *Ayala* would be permissible from a lady as well as from a man.

Señorito and *señorita* are the equivalents of Master and Miss. Señorita is used with the surname to an unmarried lady; but all ladies are *Doña*, whether married or single, which, in the case of an elderly single lady, is a great improvement on the English custom. Another privilege of Spanish women is that they do not lose their identity with marriage. For instance, if *Doña Luisa de Guzman* married the aforesaid *Don Pedro de Ayala*, she would still retain her own name among her friends, though formally, or in addressing a letter, her husband's name would be added. Her full formal address would be *Señora Doña Luisa de Guzman de Ayala.*

The children of this couple, proud of their mother's ancestry, would add her maiden name after their father's and sign themselves *de Ayala y Guzman.*

This is the origin of the long surnames so confusing to foreigners, for sometimes the names of the grandparents are also added in this way. For general purposes, however, the father's surname only is used.

The ending of a formal letter is:

Cuyas manos beso, or, *que besa sus manos, que sus manos besa*, Who kisses your hands.

Que sus piés besa, Who kisses your feet.

The last is used by a man to a woman only. This ending is nearly always abbreviated, as will be seen from the list of abbreviations given later. It is used in all correspondence, except that between tradesmen and their customers.

Model Letters

Dear Madam, I have received your letter and beg to thank you for your invitation for the 20th inst., which I have much pleasure in accepting. Yours sincerely, A. B.	Muy Sra mia, He recibido su carta y le agradezeo su amable invitacion para el 20 del Cte, que acepto con mucho gusto. Me pongo à los piés de Vd, A. B.
Mr. and Mrs. S. have much pleasure in accepting Mrs. M.'s kind invitation, and will be delighted to be present at the ball on the 29th of this month.	El Señor y la Señora de S. aceptan con mucho gusto la amable invitacion de la Señora de M. y tendrán mucho gusto en asistir al baile del 29 Cte.
My dear friend, Will you give me the pleasure of dining with me the day after to-morrow, Thursday? After dinner we will go to the Opera, and as I suppose you intend to go to the ball at the English Embassy, we can go together. Yours aff^{ly}, L. B.	Mi apreciable amigo, ¿Quiere Vd darme el gusto de comer conmigo pasado mañana, Jueves? Despues de comer irémos á la Opera, y como supongo que piensa asistir al baile de la Embajada Inglesa, podrémos ir juntos. Suyo affmo, L. B.
My dear friend, I am so sorry to have been out when you called this afternoon. I will call to-morrow at about four, in the hope of finding you at home; but if you have any other engagement don't mind; another day will do. Aff^{ly} yours, D. A.	Mi querida amiga, Cuanto siento no haber estado en casa cuando vino Vd. esta tarde. Iré á verla mañana á eso de las cuatro esperando encontrarla en casa; pero si tiene otro compromiso no importa; otro día será. Suya affma, D. A.
Dear Madam, Maria Gutierrez, who tells me that she was in your service as lady's-maid for two years, wishes me to engage her on the same terms and salary. I should be much obliged if you would give me her character. Above all I wish to know if she is strictly honest. I remain, Yours truly, B. C.	Muy Sra mia, Maria Gutierrez, que me dice haber desempeñado el cargo de doncella en su casa por dos años, solicita empleo en mi casa en las mismas condiciones y sueldo. Le agradeceré que tenga la bondad de informarme acerca de ella. Sobre todo deseo saber si es persona honrada. Quedo de Vd, S. S. S., B. C.
Dear Sir, I regret that I cannot grant your request. My present circumstances do not permit me to disburse the sum mentioned. Yours faithfully,	Muy Sr mio, Siento no poder acceder á su súplica. Las circunstancias en que me encuentro en la actualidad no me permiten desprenderme de la suma que menciona. S. S. S.,
Dear Sir, I am surprised at your silence. The business in question is of too much importance to admit of delay. Hoping for an answer by return of post, I remain, S. S.	Muy Señor mio, Me sorprende su silencio. El asunto de que se trata es por demas importante para que lo dejemos pendiente. Esperando una contestacion á vuelta de correo, Quedo de Vd, S. S.
Dear Sir, I have important business to discuss with you. Will you kindly inform me what day and hour it will be convenient for you to receive me? I remain, Your obedient servant,	Muy Señor mio, Teniendo que hablarle de un asunto importante. ¿Le suplico me diga que día, y hora, podrá recibirme? Quedo de Vd, S. S. S. Q. S. S. M. B.

Madam,
We have received your letter, and the order with which you have kindly favoured us will receive our best and earliest attention.
Yours faithfully,

Señora,
Hemos recibido su carta y la órden que tiene la bondad de pasarnos la cuál será atendida con el mayor cuidado y prontitud.
S. S. S.

Cadiz,
Hotel de Europa.
My dear Louise,
We arrived at this city on Sunday at three in the afternoon after a fine passage, and in spite of your prophecies you must know that I was not sea-sick.
On Monday night we went to the Alameda, as the chief promenade of the town is called. With one spring one might jump, so to speak, into the sea, which surges at the foot of the walls which surround Cadiz. To us, who are not used to such sights, it is marvellous. Imagine a dark night lit up by millions of stars, so clearly visible and so bright that one is almost afraid to watch them.
The English Consul introduced me to some of the principal people of the town, and they received me with the usual Spanish courtesy.
There are not many sights in Cadiz, which, as the poet says, is like a graceful and elegant sea-gull resting on the waves. What a pure and beautiful sky!
From here we shall go to Seville, Cordova, and Granada.
Your affectionate friend,
MARY.

Cadiz,
Hotel de Europa.
Mi querida Luisa,
Llegámos á esta ciudad el Domingo á las tres de la tarde, despues de una travesia hermosa, y apesar de sus profecías ha de saber que no me he mareado.
El Lúnes por la noche fuimos á la Alameda, que así se llama el paseo de esta ciudad, desde donde se podria muy bien por decirlo asi, de un brinco, saltar al mar que bulle al pié de las murallas que rodean á Cadiz. Para nosotros que no estamos acostumbrados a tales panoramos es maravilloso. Figurese una noche oscura, alumbrada por millones de estrellas, tan claramente discernibles, tan centelleantes que casi causa pavor el mirarlas.
Fui presentada por el cónsul inglés á varias personas distinguidas de la villa, quienes me recibieron con la acostumbrada cortesia española.
No hay mucho que ver en Cadiz, que como cita el poeta es parecida á una gaviota que se balancea graciosa y elegante sobre las olas. ¡Que cielo tan puro y hermoso!
De aquí irémos á Sevilla, Cordoba y Granáda.
Tu amiga que te quiere,
MARIA.

Seville,
Hotel de Inglaterra.
My dear Friend,
The Spaniards say, "Who has not seen Seville has not seen a marvel." I cannot describe this beautiful city—its handsome shops, the walk called Las Delicias, with its avenues of trees through which the sun cannot penetrate, carpeted with scented white flowers, fallen from the orange-trees which form the avenues, trees which bear fruit and blossom at the same time.
With a little imagination, one might fancy oneself carried into the Garden of the Hespérides; the Giralda, which is the name of the cathedral; the Alcazar, so full of ancient memories.
My next letter will be from Cordova.
Yours affectionately,
MARY.

Sevilla,
Hotel de Inglaterra.
Mi querida amiga,
Dicen los españoles que "Quién no ha visto á Sevilla no ha visto maravilla." No sé como describirle esta hermosa ciudad — sus encantadoras tiendas, su paseo de las Delicias con sus avenidas de árboles por donde no penetra el sol, alfombradas de blancas y perfumadas flores, caidas de los naranjos que forman esas avenidas; árboles que fructifican, y dán flores á la vez.
Con solo imaginarse un poco podría uno creerse trasportado al jardin de las Hespérides; la Giralda que asi se llama su catedral; el Alcázar tan lleno de antiguos recuerdos.
Mi proxima carta será desde Córdoba.
Suya afectisima,
MARIA.

Granada,
Hotel de la Vega.
No words can describe Granada: Granada the poetical! Granada the beautiful! Granada, the city of the Moors! It is impossible to imagine, without seeing it, the beauty and grandeur of the Alhambra; but there are so many descriptions of this palace of the Moors that I will not bother you by repeating things which we have so often read together. But it is strange that so little has been said about the Vega (Plain) de Granada.

This plain, covered with flowers, fruit-trees, wheat, and every kind of grain, is very beautiful, and those who do not know the reason are surprised at its fertility, being aware that sometimes there is no rain for six months; but the following fact solves the mystery. The Moors, who were very ingenious, built conduits communicating with the rivers Darro and Genil. At sunset a bell is rung from the Atalaya (Watch Tower), the conduits are opened, and streams of clear and limpid water irrigate the plain. Spaniards associate all kinds of poetical memories with this bell, which is called the "bell of the watch."
I have never seen anything like Granada, and, to my regret, I shall be obliged to leave tomorrow this beautiful town. Good-bye!
Your loving friend,
MARY.

Granáda,
Hotel de la Vega.
No hay palabra que pueda describir Granáda; ¡Granáda la poética! ¡Granáda la hermosa! ¡Granáda la ciudad de los moros! No se puede Vd figurar sin verla la hermosura y grandiosidad de la Alambra, pero son tantas las descripciones que existen de este palacio de los moros, que no quiero molestarla repitiendo lo que ya hemos leido tantas veces juntas. Pero es de extrañar que tan poco se haya dicho acerca de la Vega de Granáda.
Esta vega sembrada de flóres, árboles frutales, trigo, y toda clase de sementera es hermosa, y el que ignora el motivo al verla tan fructifera se sorprende al saber que á veces pasan seis meses sin llover, pero revela el misterio el siguiente hecho. Los moros que eran sagaces construyeron unos caños que comunican con los ríos Darro y Genil. A la puesta del sol se toca una campana en la Atalaya, abren los caños y el agua clara y límpida corre, regando toda la vega. Los españoles asocian toda especie de poéticos recuerdos con esta campana, llamada de la *Vela*. No he visto nunca nada que se parezca á Granáda y sintiendolo en el alma me verè obligada á marchar mañana de esta hermosa ciudad; Adios!
Tu amiga que te quiere,
MARIA.

C ntinued

ESPERANTO

Continued from page 5655

By Harald Clegg

SUFFIXES

Besides the six prefixes dealt with on pages 4656 and 5373, Esperanto possesses about twenty words, or particles, which are used as suffixes, and which affect the meaning of the root word in diverse manners as will be shown.

They will be explained gradually throughout the lessons, and will be introduced in order of importance.

In denotes the feminine gender. Example: *Frato*, brother; *fratino*, sister; *porko*, pig; *porkino*, sow.

Et denotes decrease or diminution of degree. Example: *Ami*, to love; *ameti*, to like; *monto*, mountain; *monteto*, hill; *bela*, beautiful; *beleta*, pretty.

Ul denotes a person characterised by the meaning expressed in the root word. Example: *Saĝa*, wise; *saĝulo*, a sage; *malbona*, wicked; *malbonulo*, a wicked person.

Il denotes the instrument used to perform an action. Example: *Plugi*, to plough; *plugilo*, a plough; *tranĉi*, to cut; *tranĉilo*, a knife.

Many of these suffixes lend themselves to the process of being combined in the same word. The order in which they appear depends on the exact sense to be conveyed, but the suffix which conveys the predominant meaning to the word must be placed last.

If we take *tim'* (fear) as the root word, the results of the different positions of the affixes would be as follows:

Timulo, a coward; *timetulo*, a timid person; *timuleto*, a little coward; *timetuleto*, a timid little person.

Of course, this root word could be qualified still further—*e.g.*, by the use of *mal* or *in*, and the fine shades of meaning thus obtained would give a great deal of trouble in searching for a suitable English equivalent. Moreover, the nature of these combined words very often permits the addition of the characteristics of the adjective and adverb, and we get words which can only be clumsily expressed in other languages.

Example: *Malsaĝule*, in the manner of a fool; *bokuzineto*, a little cousin-in-law (female).

Many of the suffixes, too, may, by themselves, form distinct words:

Example: *Ilo*, an instrument, a tool; *eta*, diminutive.

With regard to the suffix *in*, it may here be explained that it is not ordinarily applied to *homo*, as this word, although sometimes loosely used to point out the male sex, really means "a human being," and therefore includes femininity. When we see *homoj*, the real translation is "people," not "men." "Woman" in Esperanto is *virino*.

ADVERBS

Invariable Adverbs. The method of forming adverbs from root words has already been explained, but beyond these there are in Esperanto a number of invariable words which are by their nature essentially adverbs. These are:

adiaŭ, good-bye, adieu
almenaŭ, at least
ambaŭ, both
ankaŭ, also
ankoraŭ, yet, still
apenaŭ, scarcely, hardly
baldaŭ, soon, shortly
denove, over again, once more
eĉ, even
for, away
jam, already
kvazaŭ, as if, as it were, as though
nun, now
nur, only
plu, further, more
preskaŭ, almost, nearly
tro, too (much)
tre, very
tuj, at once, immediately.

There is little to be said in further explanation of these words, except that they sometimes lend themselves to the addition of the adjectival *a* or of a suffix:

Example: *Tuja respondo*, an immediate reply; *treege*, exceedingly; *baldaŭa venko*, an early victory.

Vocabulary

adres', address
almoz', alms
babil', chatter
bala', sweep (v.t.)
bar', bar, obstruct
blind', blind (adj.)
ĉiz', chisel, carve
*do**, therefore
drink', drink to excess
etern', eternal
fajf', whistle
fos', dig
fraŭl', bachelor
fremd', strange, unacquainted
frenez', crazy, mad
glad', smooth (to iron)
glit', glide, slide, skate
hak, hew, chop
hejt', heat (v. t.)
honor', honour
insul', island
kis', kiss
kok', cock
komb', comb
kudr', sew
kupr', copper
lam', lame
lig', bind, tie
mezur', measure (v. t.)
muel', mill (v. t.)
mut', dumb
nom', name
nord', north
orf', orphan
paf', shoot, fire
pal', pale
pek', sin
pes', weigh (v. t.)
pez', weight
pi', pious
plaĉ', please, gratify
plekt', plait, weave
plor', cry, weep
sud', south
supoz', suppose
surd', deaf
ŝerc', joke
ŝlos', lock, fasten
vidv', widower

Exercise XII.

Translate into English:

Hakilo. Vidvino. Fremdulo. Blindulino. Insuleto. Fraŭlineto. Pafilo. Frenezulino. Patrine. Fratina. Sur la stratoj oni ofte renkontas surdulojn, mutulojn kaj blindulojn, kiuj estas gealmozuloj. Mi prenis miajn glitilojn por gliti sur la glacio. La knabineto ploris ĝis kiam ŝi ne plu povis plori. Per kudrilo oni kudras, kaj per kombilo oni kombas la harojn. Estas insuletoj en ambaŭ la norda kaj suda partoj de tiu ĉi lando, sed mi ankoraŭ ne veturis al ili. Mi nun estas vidvino, ĉar mia edzo ĵus mortis. Li prenis la pafilon kaj pafis frenezule (aŭ kiel frenezulo) ĉien. Oni supozas, ke piulo neniam eĉ iomete pekas. La ŝerculo denove kisis la geinfanetojn kaj ankaŭ la fraŭlinojn. Mi estas preskaŭ certa, ke vi estas nura trompulino.

Translate into Esperanto:

Although I well know your name and address, I do not yet intend to write to you. He is an honourable man, very rich, but not too happy. He took the scales and weighed the copper. It weighed only twelve pounds. The orphan smiled as though she wished to please me. The chatterer at once began again to speak about nothing; I listened for a short time, and then would not hear more. Here is a flat-iron to iron with, and a key to lock the door. The spade and the axe are exceedingly useful implements.

PREPOSITIONS

The following is a list of the remaining Prepositions, which must be acquired by the student:

Anstataŭ instead of, in place of; *Antaŭ* (place), before, in front of.

When this preposition is used to denote time it is followed by *ol* or *kiam*. This avoids confusion, which would otherwise arise in phrases such as: *Ŝi kantis antaŭ la princino*, She sang before (in the presence of) the princess; *Ŝi kantis antaŭ ol la princino*, She sang before (previous to) the princess.

Kiam would be preferably used instead of *ol* if another verb followed the complement. Example: *Ŝi kantis antaŭ, kiam la princino alvenis*, She sang before (when) the princess arrived.

In phrases such as "Many years ago," "Three days ago," and the like, *Antaŭ* is used to translate "ago." *Antaŭ multaj jaroj, Antaŭ tri tagoj.*

Ol is always interposed when an infinitive immediately follows. Example: *Antaŭ ol komenci*, before commencing.

Apud by the side of, near
Ĉirkaŭ, around, about, approximately
Dum, during, while
Inter, between, among
Kontraŭ, against, opposite to
Krom, except, not counting
Laŭ, according to
Malgraŭ, in spite of
Post, after, behind
Preter, past
Super, above (not touching, as distinguished from *sur*)

These prepositions may often take the adverbial and adjectival form, besides allowing the addition of a prefix or affix. Example: *Mi loĝas en la apuda domo*, I live in the house next door; *Li parolis, sed dume mi dormis*, He spoke, but in the meanwhile I slept; *Kontraŭulo*, a contrary person.

When prepositions are used as prefixes to verbs it is customary, in order to emphasise the full meaning, to use them also after the verb. Example: *La reĝo eniris en la ĉambron*, The king entered (into) the room.

KEY TO EXERCISE XI.

Se vi mensogus, mi vin malestimus. La krajono nun kuŝas sur la lito, kien vi ĵus ĝin metis. Ho, mia kara bofrato, ĉu vi volus insulti vian propran parencon? Ŝi estas dekoble pli riĉa ol vi. Ju pli mi scias tion, des pli mi ŝin envias. Tiu, kiu volus esti feliĉa, devus havi paciencon. Li povas kuri po sep mejloj kaj kvin okonoj en ĉiu horo. Ĉiu litero en la Esperanta alfabeto havas apartan sonon. Mi aprobus; mi estus ja perfekte kontenta, se vi konsentus akcepti la konsilon de mia eminenta amiko. Dekunuoble dek du faras cent tridek du, kiu estas la kvarona parto da kvincent dudek ok. Li aĉetis tri kvaronojn de funto da frukto, kaj egalan kvanton da flava fromaĝo. Estas malpura makulo sur tiu libro. Ĉu vi estus preta por renkonti min, se mi atendus duonhoron? La glacio estas firma kaj ebena. Li pruvis al mi, ke la leĝoj de tiu ĉi lando estas justaj, kvankam li konfesis, ke oni bezonas multe da pacienco. Lastan nokton ni iris al la teatro kaj tie ni rapide elspezis nian tutan monon. Tio, kio koncernas min ne estas necese ĉiam via afero. Ŝi rakontis al mi ĉion, kion mi volis aŭdi. Se mi legus ĉi tiun libron po kvin dek paĝoj en ĉiu tago, mi povus ĝin resendi al vi proksiman semajnon.

Continued

GREEK

Continued from page 5657

By G. K. Hibbert, M.A.

SECTION I. ACCIDENCE
PRONOUNS

Personal Pronouns. The pronoun of the first person is ἐγώ, I; and of the second person σύ, thou.

	Singular	
Nom.	ἐγώ	σύ
Acc.	ἐμέ, μέ	σέ
Gen.	ἐμοῦ, μοῦ	σοῦ
Dat.	ἐμοί, μοί	σοί
	Dual	
Nom., Acc.	νώ, we two	σφώ, you two
Gen., Dat.	νῷν	σφῷν
	Plural	
Nom.	ἡμεῖς, we	ὑμεῖς, ye *or* you
Acc.	ἡμᾶς	ὑμᾶς
Gen.	ἡμῶν	ὑμῶν
Dat.	ἡμῖν	ὑμῖν

The nominative of the personal pronouns is seldom used, except for emphasis—*e.g.:* I save is σώζω, not ἐγὼ σώζω. The forms ἐμέ, ἐμοῦ, ἐμοί are more emphatic than μέ, μοῦ, μοῖ.

There is no pronoun of the third person in Greek, at any rate in the nominative. To translate *he*, we must use a demonstrative pronoun, such as ἐκεῖνος, that man; οὗτος, this man [see below under Demonstratives]. But for the oblique cases of the pronoun of the third person—that is, for all cases except the nominative—the cases of αὐτός, αὐτή, αὐτό, himself, herself, itself, are used. αὐτός is thus declined:

	Singular		
	Masc.	*Fem.*	*Neuter*
Nom.	αὐτός	αὐτή	αὐτό
Acc.	αὐτόν	αὐτήν	αὐτό
Gen.	αὐτοῦ	αὐτῆς	αὐτοῦ
Dat.	αὐτῷ	αὐτῇ	αὐτῷ
		Dual	
Nom., Acc.	αὐτώ	αὐτά	αὐτώ
Gen., Dat.	αὐτοῖν	αὐταῖν	αὐτοῖν
		Plural	
Nom.	αὐτοί	αὐταί	αὐτά
Acc.	αὐτούς	αὐτάς	αὐτά
Gen.	αὐτῶν	αὐτῶν	αὐτῶν
Dat.	αὐτοῖς	αὐταῖς	αὐτοῖς

Examples of the use of αὐτός: ἔσωσα αὐτόν, I saved him; ἔλεγεν αὐτοῖς, He said unto them. But in the nominative αὐτός means *self* (Latin *ipse*)—as, ὁ στρατηγὸς αὐτός, the general himself; αἱ γρᾶες αὐταί, the old women themselves. Note carefully, however, that when αὐτός is immediately preceded by the article, it means *same* (Latin *idem*)—as, ὁ αὐτὸς στρατηγός, the same general; τοῦ αὐτοῦ πατρός, of the same father.

αὐτός is often contracted with the article in this latter sense, as ταὐτό for τὸ αὐτό, ταὐτῇ for τῇ αὐτῇ. This is called *Crasis*.

Reflexive Pronouns. The reflexive pronouns have, of course, no nominative. They are three in number, one for each person: *ἐμαυτόν* (*ἐμέ αὐτόν*), myself; *σεαυτόν* (*σέ αὐτόν*), thyself; *ἑαυτόν*, himself. They are thus declined:

	Singular Masc.	Fem.	*Plural* Masc.	Fem.
A.	ἐμαυτόν	ἐμαυτήν	ἡμᾶς αὐτούς	ἡμᾶς αὐτάς
G.	ἐμαυτοῦ	ἐμαυτῆς	ἡμῶν αὐτῶν	ἡμῶν αὐτῶν
D.	ἐμαυτῷ	ἐμαυτῇ	ἡμῖν αὐτοῖς	ἡμῖν αὐταῖς

Note that in the plural the two words (the personal pronoun and *αὐτός*) appear separately. *σεαυτόν* is usually contracted into *σαυτόν*, thus;

	Singular Masc.	Fem.	*Plural* Masc.	Fem.
A.	σαυτόν	σαυτήν	ὑμᾶς αὐτούς	ὑμᾶς αὐτάς
G.	σαυτοῦ	σαυτῆς	ὑμῶν αὐτῶν	ὑμῶν αὐτῶν
D.	σαυτῷ	σαυτῇ	ὑμῖν αὐτοῖς	ὑμῖν αὐταῖς

ἑαυτόν is usually contracted into *αὑτόν*, and is declined like *αὐτός*. It must however be carefully distinguished from the oblique cases of *αὐτός*. The breathing is the only difference.

In addition to these three reflexive pronouns there is one which is sometimes called personal, but seems more properly to come under reflexive, as it is generally used as an indirect reflexive. It has no nominative singular, but the accusative is *ἕ*. (This compounded with *αὐτόν* gives *ἑαυτόν* above.)

Singular		*Plural*	
Acc.	ἕ	*Nom.*	σφεῖς
Gen.	οὗ	*Acc.*	σφᾶς
Dat.	οἷ	*Gen.*	σφῶν
		Dat.	σφίσι

Example: *καθορῶσι τὰς τῶν Κερκυραίων ναῦς ἐπὶ σφᾶς πλεούσας*, They see the ships of the Corcyreans sailing against *them* (*i.e.*, themselves; *ἐπὶ αὐτούς*, or *ἐφ' αὐτούς* would have referred to "Corcyreans").

Reciprocal Pronoun. The reciprocal pronoun is *ἀλλήλω* (accusative), one another; it has no nominative and is used only in dual and plural, in which numbers it is declined regularly, like *σοφός*.

Possessive Pronouns are declined like adjectives in *ος*. They are:

ἐμός, ἐμή, ἐμόν, my
σός, σή, σόν, thy
ἡμέτερος, α, ον, our
ὑμέτερος, α, ον, your
σφέτερος, α, ον, their (always reflexive)

For *his*, the genitive of *αὐτός* is used, as *ὁ πατὴρ αὐτοῦ*, his father (literally: the father of him).

The article is regularly used with these possessive pronouns, as *ὁ ὑμέτερος ταμίας*, your steward.

It is quite as good Greek to say *ὁ πατήρ μου* (my father), as to say *ὁ ἐμὸς πατήρ*, and so with all the others.

Demonstrative Pronouns. *ἐκεῖνος*, that; *οὗτος* and *ὅδε*, this.

ἐκεῖνος, that, is declined quite regularly like *σοφός*, except that the neuter nominative and accusative singular is *ἐκεῖνο*, not *ἐκεῖνον*.

ὅδε, this, is simply the article *ὁ* with the particle *δε* added; it is therefore declined like the article: *ὅδε, ἥδε, τόδε*; genitive: *τοῦδε, τῆσδε, τοῦδε, κ. τ. λ.* (*κ. τ. λ.* stands for *καὶ τὰ λοιπά*, and the remaining things, or et cetera.)

οὗτος, this, is declined as follows:

		Singular	
Nom.	οὗτος	αὕτη	τοῦτο
Acc.	τοῦτον	ταύτην	τοῦτο
Gen.	τούτου	ταύτης	τούτου
Dat.	τούτῳ	ταύτῃ	τούτῳ
		Dual	
Nom., Acc.	τούτω	τούτω	τούτω
Gen., Dat.	τούτοιν	τούτοιν	τούτοιν
		Plural	
Nom.	οὗτοι	αὗται	ταῦτα
Acc.	τούτους	ταύτας	ταῦτα
Gen.	τούτων	τούτων	τούτων
Dat.	τούτοις	ταύταις	τούτοις

When these demonstrative pronouns are used as adjectives with a noun, the article is regularly used—as, *οὗτος ὁ ἀνήρ*, this man; *ἐκείνη ἡ μήτηρ*, that mother.

Interrogative and Indefinite Pronouns. The interrogative pronoun is *τίς, τί*, who? what? The indefinite pronoun is *τὶς, τὶ*, anyone, anything, or someone, something The only difference between them is that of accent: the former always takes the accent on the first syllable, while in the latter the accent belongs to the last syllable. The latter, being an enclitic, usually drops its accent altogether. (This will be explained later under Accentuation.) They are thus declined:

	INTERROGATIVE Masc. & Fem.	Neuter	INDEFINITE Masc. & Fem.	Neuter
		Singular		
Nom.	τίς	τί	τὶς	τὶ
Acc.	τίνα	τί	τινά	τὶ
Gen.	τίνος, τοῦ		τινός, του	
Dat.	τίνι, τῷ		τινί, τῳ	
		Dual		
Nom., Acc.	τίνε		τινέ	
Gen., Dat.	τίνοιν		τινοῖν	
		Plural		
Nom.	τίνες	τίνα	τινές	τινά
Acc.	τίνας	τίνα	τινάς	τινά
Gen.	τίνων		τινῶν	
Dat.	τίσι		τισί	

Note. *τί* (interrogative) can mean "why?" as well as "what?"

For the indefinite neuter plural *τινά* the form *ἄττα* is sometimes used. Examples: *τίνα ἔσωσας*, Whom did you save? *τίνας ὄρνιθας ἔχουσιν*, What birds have they? *ἄνθρωπός τις*, some man; *τοῦτο λέγει τις*, Someone says this.

ἄλλος, other, is declined like *ἐκεῖνος*.

Relative Pronouns. The ordinary relative is *ὅς, ἥ, ὅ*, *who*, and is declined as follows:

	Singular			*Dual*			*Plural*		
N.	ὅς	ἥ	ὅ	ὥ	ἅ	ὥ	οἵ	αἵ	ἅ
A.	ὅν	ἥν	ὅ	,,	,,	,,	οὕς	ἅς	ἅ
G.	οὗ	ἧς	οὗ	οἷν	αἷν	οἷν	ὧν	ὧν	ὧν
D.	ᾧ	ᾗ	ᾧ	,,	,,	,,	οἷς	αἷς	οἷς

NOTE. The forms *ἥ, οἵ*, and *αἵ* are distinguished from the similar forms of the article by having an accent.

There is also an indefinite relative pronoun, compounded of ὅς and the indefinite τὶς: ὅστις, whoever:

		Singular	
Nom.	ὅστις	ἥτις	ὅ τι
Acc.	ὅντινα	ἥντινα	ὅ τι
Gen.	οὗτινος, ὅτου	ἧστινος	οὗτινος, ὅτου
Dat.	ᾧτινι, ὅτῳ	ᾗτινι	ᾧτινι, ὅτῳ
		Dual	
Nom., Acc.	ὥτινε	ἅτινε	ὥτινε
Gen., Dat.	οἷντινοιν	αἷντινοιν	οἷντινοιν
		Plural	
Nom.	οἵτινες	αἵτινες	ἅτινα, ἅττα
Acc.	οὕστινας	ἅστινας	ἅτινα, ἅττα
Gen	ὧντινων, ὅτων	ὧντινων	ὧντινων, ὅτων
Dat.	οἷστισι, ὅτοισι	αἷστισι	οἷστισι, ὅτοισι

Note that each part is declined separately, and that ὅ τι is written as two words to distinguish it from the conjunction ὅτι, that, because.

Regular Verb. λύω, I loose.

		Perf. Ind.	*Pluperf. Ind.*
1.	*Singular*	λέλυκα, I have	ἐλελύκειν, I had
2.	,,	λέλυκας loosed	ἐλελύκεις loosed
3.	,,	λέλυκε(ν)	ἐλελύκει(ν)
2.	*Dual*	λελύκατον	ἐλελύκειτον
3	,,	λελύκατον	ἐλελυκείτην
1.	*Plural*	λελύκαμεν	ἐλελύκειμεν
2.	,,	λελύκατε	ἐλελύκειτε
3.	,,	λελύκασι(ν)	ἐλελύκεσαν

Most verbs beginning with a consonant form their perfect by *reduplication*—*i.e.*, by prefixing the initial consonant followed by ε—as: λύω, λέλυκα; γράφω, I write, γέγραφα; σώζω, σέσωκα. In these cases, the pluperfect prefixes to the perfect the syllabic augment ε.

SECTION II. SYNTAX

Rule 1. A relative pronoun agrees with its antecedent in number, person, and gender, but not in case. Its case depends on the construction of the clause to which it belongs—as, ὑμεῖς οἳ τοῦτο γράφετε, You who write this; οἱ στρατιῶται οὓς σέσωκά εἰσι δειλοί, The soldiers whom I have saved are cowardly; οἱ ποίμενες οἳ τὸν λέοντα κτείνουσίν εἰσιν ἀνδρεῖοι, The shepherds who are killing the lion are brave.

Rule 2. *Duration of time* is expressed by the accusative case—the answer to the question "How long?"—as, They were a long time in the island, ἦσαν μακρὸν χρόνον ἐν τῇ νήσῳ; He stayed for three days, ἔμενε (μένω = I remain) τρεῖς ἡμέρας.

Rule 3. *Time when* (definite) is expressed by the dative case—the answer to the question "When?" "At what time?"—as, τῇ πρώτῃ ἡμέρᾳ, on the first day; τῇ αὐτῇ νυκτί, on the same night.

Rule 4. *Time when* (indefinite) or *Time within which* is expressed by the genitive—the answer to the question "Within what time?" "During the course of what time?" as: χειμῶνος, in winter time; νυκτός, by night; ὀλίγου χρόνου, within a short time. Time may also be expressed by prepositions, as ἐν τῇ νυκτί, in the night.

Rule 5. The participle, with the article prefixed, may be used as a substantive—as, οἱ λέγοντες, the speakers. But most commonly the participle with article represents an English relative clause—as, τὰ λεγόμενα, the things that are being said; οἱ εὖ ζῶντες, those who live well (εὖ has smooth breathing, not rough); ὁ ταπεινῶν ἑαυτόν, he who abases himself; ὁ φιλῶν τὴν ψυχὴν αὐτοῦ ἀπολέσει αὐτήν, He that loveth his life (soul) shall lose it.

Exercise VI.

frog, ὁ βάτραχος, -ου
once, ποτέ
I send, πέμπω
ambassadors, οἱ πρέσβεις
Jupiter, ὁ Ζεύς (*acc.* Δία)
marsh, ἡ λίμνη
depth, τὸ βάθος, -ους
as, ὡς
motionless, ἀκίνητος
they despised, κατεφρόνουν (imperfect of καταφρονέω—governs genitive)
I think, νομίζω
to be, εἶναι
I ask, αἰτέω (*aor.* ῄτησα)
to provide, παρασχεῖν
I throw, ῥίπτω (*aor.* ἔρριψα)
log of wood, τὸ ξύλον
unworthy, ἀνάξιος
fool, μωρός
water-serpent, ἡ ὕδρα
by, ὑπὸ (governs genitive; ὑφ' before an aspirated vowel)
they were eaten up, κατησθίοντο (imperfect passive of κατεσθίω, I eat up).

1. The frogs once sent ambassadors to (ἐπί with accusative) Jupiter and asked (him) to provide a king for them. 2. Jupiter threw a log of wood into the marsh. 3. The frogs in fear threw themselves into the depths of the marsh. 4. But as the log was motionless, they soon despised it, and thought this king to be unworthy. 5. They asked Jupiter (for) another king. 6. He said "Ye are fools," and sent them a water-serpent, by whom they were eaten up.

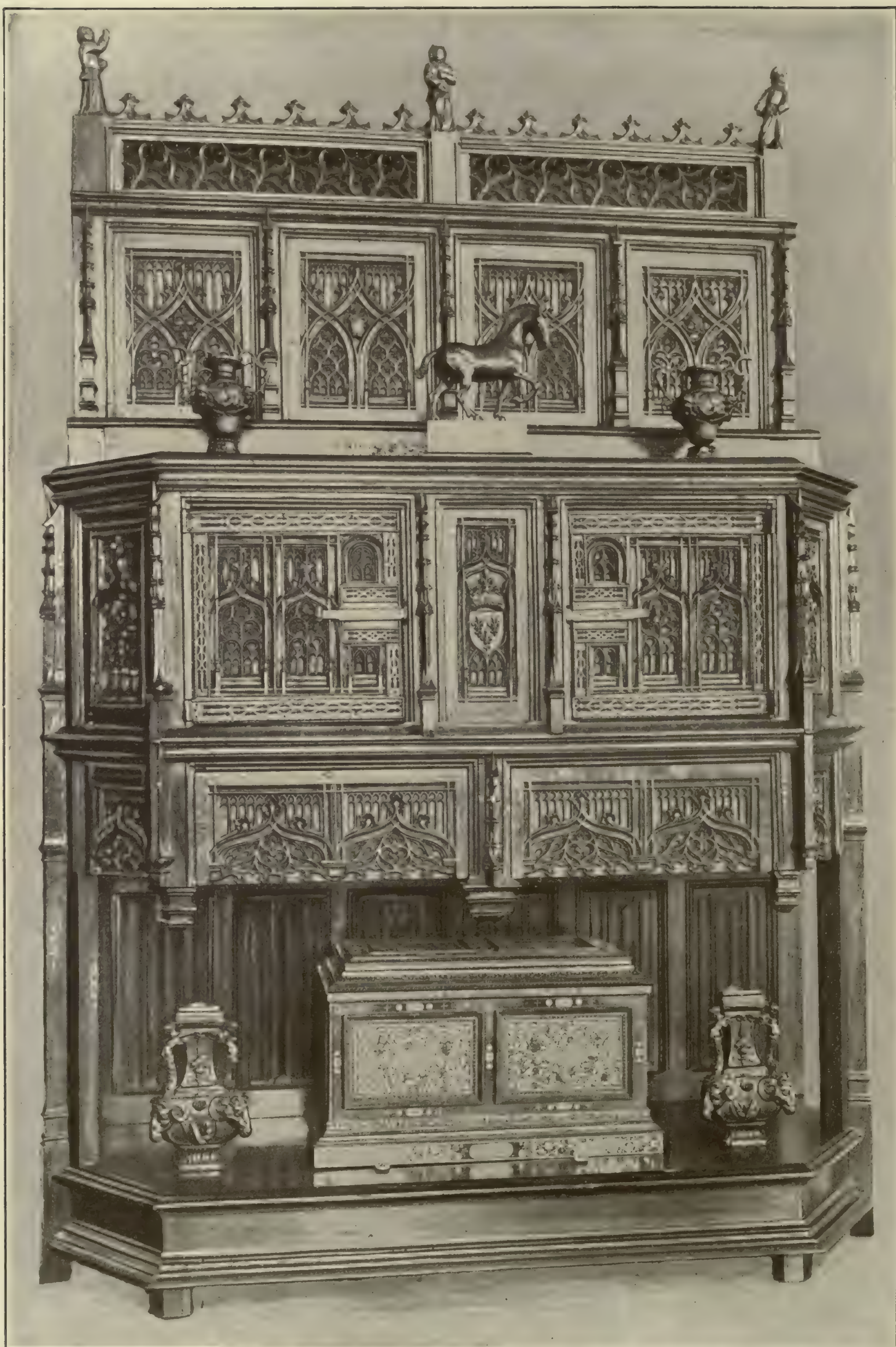
Key to Exercise V.

1. ἐνταῦθα Κύρῳ βασίλεια ἦν καὶ παράδεισος μέγας θηρῶν πλήρης. 2. ὁ βασιλεὺς ἐθήρευε τοὺς θῆρας ἀπὸ ἵππου (generally written ἀφ' ἵππου). 3. διὰ τοῦ παραδείσου ῥεῖ ὁ Μαίανδρος ποταμός (note the order), καὶ αἱ τοῦ ποταμοῦ πηγαὶ εἰσὶν ἐκ τῶν βασιλείων. 4. ῥεῖ διὰ τῆς πάσης πόλεως. 5. οἱ πάλαι ἔλεγον ὅτι ἐνταῦθα Ἀπόλλων ἔκτεινε Μαρσύαν. 6. ἐνταῦθα Ξέρξης, ὁ τῶν Περσῶν βασιλεύς, ἐποίησεν ἀκρόπολιν καὶ βασίλεια. 7. μεγαλύνει ἡ ψυχή μου τὸν κύριον, καὶ ἠγαλλίασε τὸ πνεῦμά μου ἐπὶ τῷ Θεῷ τῷ σωτῆρί μου. 8. πᾶν δένδρον ἀγαθὸν καρποὺς καλοὺς ποιεῖ· τὸ δὲ* σαπρὸν δένδρον καρποὺς πονηροὺς ποιεῖ. [Literally: Every good tree bringeth forth *beautiful* fruit.]

* δέ is one of the commonest of the Greek *Particles*. In any continuous passage of Greek, each sentence is generally connected with the preceding by some connecting particle. Some of these particles, such as δέ, are never the first word of a sentence, but generally the second. δέ means *and* or *but*, according to the context. The particles will be fully explained later on.

Continued

The next instalment of the Italian Course appears in Part 41 of the Self-Educator



AN EXAMPLE OF CARVED WALNUT-WOOD: DRESSER IN LATE FRENCH GOTHIC STYLE, ABOUT 1500 A.D.

Photographed at the Wallace Collection by W. A. Mansell & Co.

See CARVING

SIMPLE WOOD-CARVING

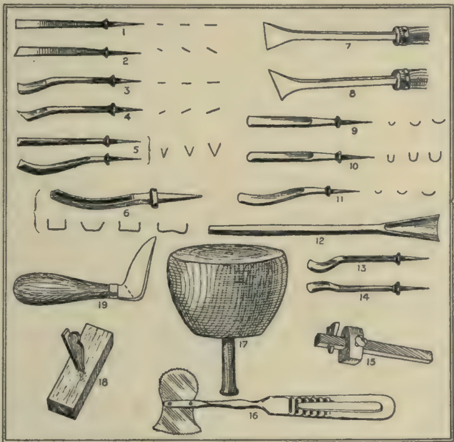
Suitable Woods for Carving. The Difficulties and Mysteries of Grain. Carvers' Tools. Transferring the Design. Chip-carving in Straight and Curved Lines

Following EARTHENWARE from page 5778

By F. WELLESLEY KENDLE

ALL wood that is to be used for carving should be well seasoned, free from sapwood, knots, flaws, bruises, cracks, shakes, and nails, with straight grain and but little figure.

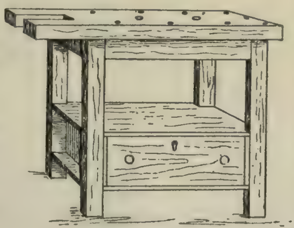
Some Suitable Woods. White deal, yellow deal, and American whitewood are soft and readily worked—too soft, indeed, for fine work, but affording capital training for the novice, who requires constant care and alertness in order to avoid accidents to himself and his material. Red deal is nice and soft, but the resins in which it is so rich clog the tools and make delicate work impossible. Plane does not split readily, and consequently can be carved into very great detail. Lime, pear, and sycamore are tougher, with nice easy grain. Kauri and Hungarian ash are both ideal woods for the carver of furniture intended for bed-room suites. Cedar is delightfully free, but very brittle. Walnut and American walnut are fairly hard, cut well, are durable, and take a good polish. Mahogany, in spite of its hardness and propensity for splintering, is not particularly difficult to carve, though the earthy salts it contains cause it to blunt tools very rapidly. Box, ebony, and coconut are close-grained, exceedingly hard and intractable, and only fitted for work for which unlimited time can be spared. Chestnut is tough, and rather troublesome to carve, though when finished, its colour, tone, and durability make it a formidable rival to oak.



CARVERS' TOOLS
1, 2, 3, and 4. Firmers **5.** Parting tool **6.** Macaroni **7 and 8.** Spade tools **9.** Gouge **10.** Fluter or U-tool **11, 12, 13, and 14.** Gouges **15.** Gauge **16.** Hey's saw **17.** Mallet **18.** Router **19.** Carver's knife

The Va ue of Oak. Oak is universally admitted to be the favourite wood from which to fashion household and ecclesiastical furniture. The grain is a little tricky at first, but when once the carver has mastered its peculiarities, he will prefer it to all others, as did his ancestors, for it was in oak that their finest church work was executed; oak dower chests held their wardrobes; oak beds, benches, and settles rested their limbs; oak beams framed their dwellings; oak rafters supported their roofs, and oak panels furnished their rooms. No other wood withstands damp so well or improves so greatly with age. Besides the above, satin-wood, maple, bird's-eye maple, acacia, cherry, rosewood, olive, apple, ash, birch, beech, teak, camphor, Brazil-wood, bamboo, sandal-wood, and ironwood are all frequently employed. [See MATERIALS AND STRUCTURES, pages 51–57.]

The Mystery of Grain. On examining a transverse section of any exogenous wood it is seen to be built up of concentric layers, around an almost central axis. The outer portion of each ring is denser than the inner. A longitudinal section reveals the fact that these layers can be separated from one another, permitting the wood to split lengthways. Each layer is composed of myriads of bundles of more or less fusiform cells, the long axes pointing in the direction of the growth of the tree. When wood is cut longitudinally the tool travels evenly between these fibres; when obliquely, they have a tendency to deflect it and guide it to a course parallel with themselves; when transversely, it continually changes the rate of its penetration, according as the soft or hard portions of a layer offer little or much resistance. Herein lies the crucial difficulty of wood-carving, for each species of wood and each separate plank presents its own peculiarities, which no amount of book learning or verbal description can possibly teach, and only constant practice can enable the student to master. No training will educate the beginner to overcome the mysteries of grain so quickly and pleasantly as chip-carving; it may not be the highest form of art, but it is executed with comparative rapidity, and the carver soon has something to show for his trouble. When, later on, he attempts the more advanced styles, he will find that he has already mastered most of the difficulties that they present.



20. CARVER'S BENCH

Tools. Carvers' tools differ very materially from those used by the carpenter and joiner, for whereas the latter are wrought from one plate of steel and another of iron welded together, and are sharpened on one side, the former have a steel plate between *two* layers of iron, and are sharpened on both sides, leaving a central cutting edge. Those chiefly used are given below.

FIRMERS. Shaped like a carpenter's chisel [**1**].

SKEW FIRMERS. A flat-bladed tool similar to **1**, but with cutting edge set obliquely [**2**].

SPADE FIRMERS OR SPATULAS. A spade-shaped flat blade welded to a square iron shaft. The edge is set either on the flat or skew [**7** and **8**].

21. CARVER'S SCREW

ENTERING TOOL, FLAT-BENT FIRMER, OR BENT GROUNDER. The blade has a double bend near its extremity to allow it to be used below the original surface of the panel. The edge is set flat or right or left skew [**3** and **4**].

22. LONG DOG

PARTING TOOL OR V. The name is descriptive, the cutting edge resembling the letter V. The shaft of the blade is either straight or up-curved [**5**].

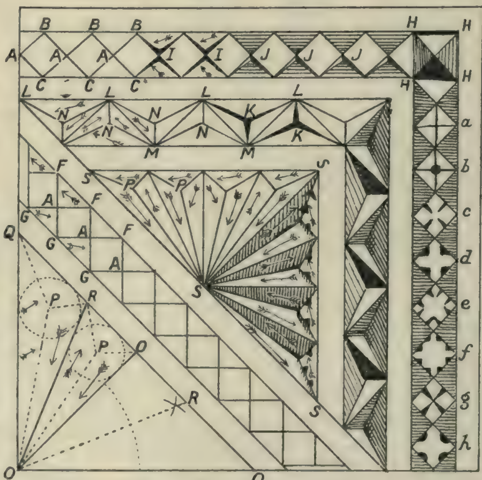
GOUGE. The section of a gouge is an arc. It is said to be *quick* or *flat*, according as the radius is less or more than ½ in. An extra flat gouge is hardly to be distinguished from a *firmer*. A gouge whose blade is ¼ in. across is quicker than one with a similar sweep, but wider [**9**].

FLUTER, VEINER, OR U-TOOL. Similar to a very quick gouge, with an acuter curve than an arc [**10**].

MACARONI. In several shapes, either like a half-H or a truncated V; sometimes with rounded corners, sometimes with a curved base [**6**].

Gouges are made with *up-curved blades*, and also with *front* and *back bends* [**11**, **12**, **13** and **14**].

CARVER'S, OR NORWEGIAN CHIP KNIFE. Has a blade with edge recurved towards the point which is in a straight line with the back, the whole being fixed almost at a right angle into a stout wooden handle [**19**].



23. CHIP-CARVING

ROUTER. A narrow *firmer*, driven through a flat piece of very hard wood at a steep angle, the edge projecting to the depth of the intended groundwork [**18**].

MOULDER, SINKER, OR SCRATCH. A somewhat similar contrivance made from a piece of waste steel filed to the desired profile, and driven through a bar of wood furnished with a travelling guide like that of a *bar compass* or *trousquin* [**15**].

MALLET. A 5-in. stonemason's mallet, or a bottle-shaped *maul* are both preferable to a square-faced tool [**17**].

SAW. In addition to a small *tenon* and a *fret-saw*, a very useful model is that known as *Hey's saw*, such as is used by surgeons in operations upon the skull [**16**].

BENCH. A wood-carver's bench [**20**] should be very firm and heavy, with a solid top of chestnut or elm, 3 × 24 × 42 in. It should be high enough to permit the workman to rest his elbows comfortably upon it when standing. It is convenient to have it fitted with a deep drawer for tools, etc., within 9 in. of the ground. An invaluable adjunct is a good lever vice. The top should be perforated with a few holes to allow holdfasts, carvers' screws, and "long dogs" to be used.

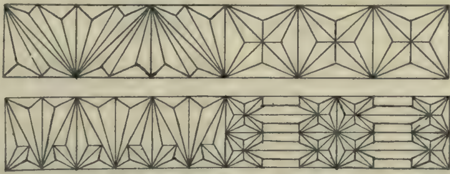
CARVERS' SCREWS, used by screwing them into the under-surface of the panel to be carved, passing through holes in the bench, and fixing by a winged traveller. They offer no obstruction to the carver, but he must be careful to insert them opposite to some portion of the design not to be cut away, lest the protruding point should injure a cutting tool [**21**].

LONG DOG. A long screw furnished a-top with an iron cross-piece or *snib* [**22***a*], and below with a *sycamore* nut [**22**].

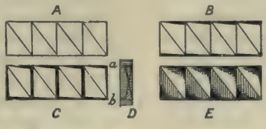
Transferring the Design to the Wood. Having determined upon the design, it must be transferred to the wood. If the carver be a good artist, he may sketch in the outline and leading features. He will find it a great assistance to rule the copy and the panel into corresponding chessboard patterns, filling in the details of the several squares; or he may superimpose a frame, strung with cross strands of silk or fine wire, above the drawing. By this simple device he can enlarge or diminish with great accuracy; or he may use a *pantograph*, or trace it with a style and carbon, calamine, blanc d'Espagne, or Prussian blue transfer paper, all of which he can easily manufacture by greasing unsized paper with spermaceti and rubbing in the required pigment. He may impress the design upon the wood with a style, pricker or tracing wheel. Time may be saved by cutting a stencil of one section of the design and stippling with thick size to which a pigment has been added. Lastly, he may paste the pattern itself upon the wood, always remembering that wet paper stretches, that wet wood warps, and that the pattern is destroyed for ever.

Chip-carving. The essence of chip-carving, or spot carving, is that a more or less geometrical design is gradually built up by the removal of triangular or irregularly-shaped chips.

Fasten a $\frac{3}{8}$-in. board of deal or whitewood, 10 in. square, flush with the right-hand corner of the bench, with the grain running right and left. Leaving a $\frac{1}{4}$-in. margin, set out a complete border of $\frac{1}{2}$-in. squares. Through each square draw two diagonals [23]. Select a skew firmer a trifle wider than half a diagonal. Grasp the handle firmly, guiding it with the left hand, till the point lies on an A and the edge along the line AB. Press the tool into the wood till the point has bitten to the depth of about $\frac{1}{8}$ in., the heel only just marking the surface. Repeat along each AB. The wood will be scored as at II. Turn the tool on its flat at such an angle that when entered along BB it will reach the bottom of the perpendicular cut by the time it reaches A. Lift out the chip BAB. The beds from which the chips are removed should appear as at JJ. Should the grain dip in places and lead the tool to bury itself too deeply change the direction of the cut from left to right. A slightly oblique thrust is less prone to be led astray by the grain than a straight forward one.



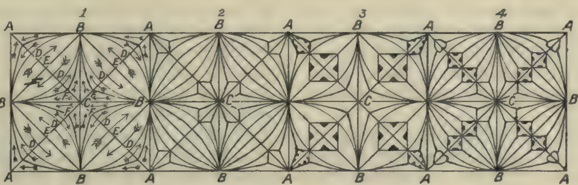
24. CHIP-CARVING DESIGNS



25. CABLE PATTERN CHIP-CARVING

A. Border *B.* First cuts *C.* Second cuts *D.* Section of second cuts through *a b* *E.* Appearance when completed

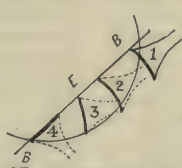
Continue till all the horizontal rows have been dealt with. Now treat the perpendicular rows similarly. Here again, avoid a straight cut; let the firmer travel diagonally across the grain, taking what advantage it can of the direction of the fibre. When all the sections have been removed, a border of flat diamonds will remain. These can be left plain, or their edges notched as suggested at *a b c*, etc.



26. CHIP-CARVING DETAILS AND DESIGNS

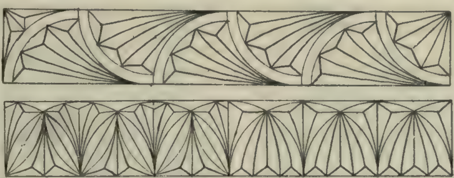
Next attack the four corner squares. Sink from the centre to each H, and remove all the triangular sections, leaving an inverted pyramid. Or with a $\frac{1}{2}$-in. straight firmer sink along each HH; then with the skew carefully remove the top and bottom, and then the side chips, starting every time from the centre. This is rather troublesome, the difficulty being to get the edges of the pyramid regular. Leave a $\frac{1}{4}$ in. strap, and construct the diamond and straps as indicated. Remove sections AFF, AGG, working in the direction of the arrows. Set out inner border LNM. Sink as at KK. Remove all the sections, making each cut in the direction indicated by the arrows. Set out central star and four corner fans, joining each angle of a triangle to the centre of a circle inscribed within it. Sink along each of these lines, starting from P. Remove the sections as before.

Working with the Carver's Knife. Execute a similar panel on the lines suggested in 24, but work entirely with the carver's knife. A particularly effective border, known as the cable pattern, is figured in 25. Execute it with skew firmer and again with carver's knife.



27. POSITIONS OF THE TOOL IN CHIP-CARVING CURVES

How Curves are Executed. By the introduction of circles a different knife-stroke is required. Set out a border 2 in. wide [26]. Divide it into squares AAAA. Inscribe a circle in each, joining the centres CCCC. Let fall a perpendicular BCB through each. From each centre A, at the distance AB, describe semi-circles. Draw diagonals through every square. Sink the long axis BEB of each spindle BD, BD from $\frac{1}{8}$ in. deep at E to nil at BB. Remove the segments BDB with a flattish gouge, preferably a spade-shaped tool, concave surface upwards. Enter a point at B, thrust it along till it has reached E, when the direction of the cut is changed by swinging round the tool in order that its other point may finish up at the far end of the line BB [27]. Work with the arrows. Map out the rest of the design as indicated in 1, 2, 3, or 4 of 26. Whichever is selected, the segments bordering on the circumference of the circles must be removed with the concave surface of a very flat gouge, an ordinary firmer, or a knife. The variety of design is infinite, and each can be enriched with bands, fillets, grooves, veins, stippling, balls, hearts, crosses, interla ings and overlays [28].



28. CURVED CHIP-CARVING DESIGNS

Continued

Group 3
SOCIOLOGY
15
Continued from page 5674

THE REAL DRINK QUESTION

The Real Evil of Alcohol. Destructiveness of Alcohol throughout Society, and Industrial and Chronic Drinking. How Science has Vindicated the Temperance Reformers

By Dr. C. W. SALEEBY

According to the latest authority on the subject, "The disorders of development in the offspring that may result from parental intoxication, whether by alcohol or by other poisons, are, of course, very diverse in character and extent; they vary from slight degrees of mental instability to the lowest grades of idiocy, and from a moderate enfeeblement of vitality to an extreme defect expressed in still-birth or abortion. They are, in their action, essentially similar to the effects obtained by experimental intoxication in the lower animals. Combemale, for instance, found that pups begotten on a healthy bitch by an alcoholised dog were congenitally feeble, and showed a marked degree of asymmetry of the brain." "In the most varied forms of defect—amongst idiots, epileptics, prostitutes, feeble-minded criminals, and, in short, in all the abnormal classes, parental alcoholism is one of the most frequent antecedents." The facts are not only to be expected, not only would any other facts be inexplicable and incredible, but they have now been collected in such overwhelming numbers that any further dispute about them is idle.

Children Born into Drink. There remains, however, the argument that alcohol may be of use to society at large by acting as an eliminating agent which weeds out bad stock. We know, of course, that bad stocks tend to become alcoholic. Is it not as well, then, that they should be allowed to destroy themselves by this means as quickly as possible? The answer to this argument is that, in the first place, the nervous degeneracy or the belonging to a bad stock as an influence "in causing intemperance is practically negligible in comparison with the influence of industrial conditions." However completely it may serve us by eliminating bad stock, we have to reckon with "its detrimental action on the healthy stocks which are exposed to its influence as a consequence of their social environment. So that in the ultimate result, alcoholism may be counted on to make a good many more degenerates than it is likely to destroy."

Disastrous and ominous beyond words is the extension of drinking amongst women in consequence of modern industrial developments. All the human evidence shows, as does also all the varied experimental evidence obtained from the lower animals, that alcoholism in the mother is far more disastrous than in the father; that nothing else could be so will be evident to the reader who closely followed our argument with the students of heredity. For the first nine months of its life the overwhelmingly preponderant factor in the environment of every human being is its mother's blood. If this contains alcohol the child receives it and may be converted into a drunkard before its birth. After birth the same process may continue by the transmission of alcohol with the mother's milk. The difference between the two cases—before and after birth—is merely one of detail. Neither has anything to do with heredity proper, but is simply a question of the consequences of feeding a young organism with poison.

The Unspeakable Evil of Alcohol. It is also worth noting that alcoholism is a frequent cause of inability to suckle. The child is therefore fed artificially, a difference which, on the average, multiplies its chances of death by about thirty, whilst even if it survives it is very rarely indeed anything like as fine an organism as it might have become.

All questions, then, as to precisely how alcohol affects the physique, including the nervous tissues, of the next generation are irrelevant and superfluous to us. We may leave it to academic authors to decide whether the proper term is deterioration or degeneration; whether it is really a question of heredity or of environment before birth, or after birth, or both. The great indisputable fact is that alcohol not merely kills the parent but poisons the child—especially through the mother—and there can be little doubt that by far the gravest of the evils which alcohol brings upon any society is its effect upon the only kind of wealth that counts—the health, the vigour, the *moral* of the people who compose it.

So much, then, for our present consideration of the physical aspects of alcohol as it affects a society. Our discussion of it has not been irrelevant to sociology, for a society is a structure made up of units composed by living matter, and the extensive use of a poison in any society is not merely a matter for the doctor or the pathologist, but intimately concerns the sociologist also. He knows that what are called the diseases of society are to be traced in the last resort to causes found in the individual —causes both physical and psychical.

Alcohol and the Man. It is necessary for us, then, before we can understand in a scientific fashion the relation of alcohol to these social diseases, to study in the briefest possible way, and without undue reference to the scientific interpretation of the facts, the actual consequences which alcohol produces in the individual. We shall not concern ourselves at all with, for instance, its effects upon the stomach. These do not concern the sociologist in any appreciable manner, but we have already recognised that alcohol is taken for its action upon the nervous system—that is to say, for its action upon that part of a man which is immediately

concerned in the essential aspects of his life as not a creature that breathes and digests and excretes, but *a being that wills and acts.* Whatever affects the willing and the action of a man is of the profoundest concern to the sociologist, who knows that human nature is the key to sociology, and who, if he be a wise man, recognises that morbid human nature is the key to social disease or social pathology.

A Being Who Wills and Acts. After all, here is only one more illustration of the great Spencerian analogy between the individual and the social organism. Students of disease in the individual organism went on for centuries, making scarcely any progress until, shortly after the discovery of the cell theory, there arose a great German student, Rudolf Virchow, the founder of modern pathology, who traced disease to the cell and interpreted it in terms of the cell, as his epoch-making book, "Cellular Pathology," indicates. The student of the diseases of the social organism must learn from the pathologist. He must pay less and less attention to all other factors and more and more attention to the health and disease of the individual man, who is a component cell of the society in which he finds himself. In the light of such conceptions, social diseases—notably, for instance, crime—become intelligible, and the miserable and brutal inefficacy of mere vindictive punishment—to describe which the noble name of Justice is prostituted—is brushed aside in the purpose to find some means whereby the diseased cell—the criminal—may be restored to health, giving new worth to his life and making it valuable instead of dangerous to his fellow-men. Since the ultimate unit of society, then, is a being who wills and acts, we must ask ourselves how this will and action are affected by alcohol; and our first necessity is to rid ourselves for once and all of an extremely widespread and unfortunate delusion.

Drunkenness is Not the Worst Effect of Alcohol. The temperance crusade from the first has been a crusade against drunkenness. Alcohol might or might not be a good thing in reasonable quantities. Some fortunate people could employ it without ever becoming drunk, or, as we say, "the worse for liquor." It was assumed, and is still popularly believed, that to be drunk and to be "the worse for liquor" are one and the same thing—the two terms being co-extensive. It is drunkenness and simply drunkenness—that is to say, acute alcoholic intoxication—that has excited the interests and the enthusiasm of temperance workers. This it is that must be put a stop to. Their only objection to the habitual use of alcohol has been that it is apt to lead to drunkenness, or, as they say, to excess.

Now, doctors have long known—though not so long as they should have known—that all this manner of looking at the subject is radically false. Alcohol is a substance of paradoxes which can be traced through its whole study; and, just as when it appears to make us warm it is lowering our temperature, so, when it appears to be doing most harm it is doing least harm. From the point of view of the doctor, mere drunkenness, or acute alcoholic intoxication, is an extremely unimportant factor in the production of disease. He is familiar with the fact that tens of thousands—or, rather, one should say millions—of men in this country occasionally become intoxicated, or even perhaps regularly so once a week, without any very disastrous consequences to themselves or to others, so far as crime and insanity and their allies are concerned. We are not now considering the terrible question of the misapplication of the workman's wages whilst his children starve. On the other hand, the doctor is familiar with cases of terrible and fatal disease of mind and body, often fatal to self and often fatal to others, in men and women (the proportion of the latter being constantly on the increase) who have never been drunk in their lives.

Alcohol a Working-class Problem. In the book to which we have referred Dr. Sullivan brilliantly brings out from the sociological side the significance of these facts, which are now at last familiar to doctors. Generally speaking, drunkenness, or acute alcoholic intoxication, is associated, especially amongst the working classes—and the problem of alcohol is in the main a problem of the working classes, from whom all other classes are recruited—with what may be called convivial drinking, drinking done after work hours in company and constituting the chief pleasure of the workman's life. We are not making the monstrous suggestion that drunkenness is a good thing or an excusable thing, and it is impossible for us, as sociologists, to forget that, even if drunkenness did no harm to the drunkard, yet, as Messrs. Rowntree and Sherwell have proved, on the average one-sixth of the total income of the working-class family in this country is spent upon alcohol, with social consequences affecting wife and children which are almost too appalling to contemplate.

In this direction, of course, drunkenness leads to social weakness, inefficiency, and loss of social happiness. But its importance as a cause of what is commonly meant by social diseases has been greatly over-estimated. The most disastrous consequences of alcohol are not the most obvious ones. Thus the death-rate from alcoholic disease, and the rates of crime and suicide, are found to be high where drunkenness is low, and vice versâ. What may be called normal drunkenness—that is to say, acute alcoholic intoxication, taking its ordinary course in a person otherwise fairly healthy—is of very little importance so far as the social diseases are concerned.

The Folly of Arguing from Appearances. The case is utterly different with drunkenness occurring in a chronic alcoholic. In such it will lead to suicide and many forms of crime, including murder. The common statistics designed to show how much crime drunkenness is responsible for are utterly fallacious, since they include all the cases of "drunk and disorderly," or "drunk and incapable," and

therefore amount to saying no more than that drunkenness is a cause of drunkenness—which needs no statistical demonstration. The case against alcohol is immeasurably too strong to need such arguments, and if it really did need such arguments to help it, so much the worse for it. We must not be misled, therefore, and, indeed, we shall find, when we come to study the subject without bias, that mere drunkenness as such is a comparatively unimportant fact, and also that an immense amount of energy and labour have been expended upon it that should have been spent upon far greater evils, which, unfortunately, happen to be less obvious. If all the grave evil done by alcohol were as obvious and palpable as mere drunkenness, it would have been utterly stamped out in every civilised country long ago. The trouble is that so few of us think, and that we are so easily carried away by outside appearances. Our blind phrase, "the worse for liquor," furnishes a particularly good illustration of this universal human tendency.

The Wreckage of Personalities. Of convivial drinking leading to drunkenness, then, we say that it is, of course, a low and bestial form of pleasure. We pray for the day when education, whether of the mind, opening it to the delights of knowledge, or of the ear, opening it to music, or of the eye, opening it to pictures and all kinds of natural beauty, may prevent many or any amongst us from seeking their highest delight in such entertainment. We may hope also for the abolition of married women's labour and for the training of girls in housewifery and cooking, so that the workman's home may become a place where he is happy, and comfortable, and content. But whilst we do nothing to this end, we shall hesitate to condemn him for finding peace and exhilaration by the use of means which we, if we were he, would similarly employ; and, meanwhile, we shall turn our attention to the vastly more important matter of what may be called *industrial drinking,* leading to *chronic alcoholism,* with its sequels of suicide, insanity, crime, pauperism, moral, mental, and physical worthlessness. This involves the most appalling losses to society, even if we adopt the vulgar estimate of money. We see them to be still more appalling if we adopt some means of estimate worthy of our spiritual state; and since, so far as our eyes can see, it yearly involves the wreckage and total loss of human personalities or souls, which are the highest things known to us, we shall realise that if there is any subject in the world that demands the thought and effort of men worthy to be called men, it is this.

Chronic Alcoholism and Society. Chronic alcoholism is a purely medical term, but, as we have seen, it concerns us here because, apart from all the changes in other organs, it is primarily a diseased state of the nervous system, and—such is the constitution of man—right willing and action cannot be found in association with a nervous system that is poisoned, diseased, and degenerate. Here we do not concern ourselves at all with chronic alcoholism as a disease tending towards death, though the sociological and national significance of unnecessary death is a subject worthy of, and yet awaiting, some great student. Our concern here is with chronic alcoholism in its relation to the diseases of society, and the first question which we must ask ourselves is as to the conditions which produce it.

Despite the reiterated and brilliant teaching of Dr. Archdall Reid, we may be well assured that in civilised societies, as we know them to-day, heredity as the predisposing factor of chronic alcoholism is an all but irrelevant and negligible factor. The importance of neglecting this proposition will be evident if we realise the practical propositions to which it leads. These are that all efforts to suppress drinking are, in effect, efforts to encourage drinking, since they simply prevent alcohol from killing off the stocks which are susceptible to its influence; and that the sole form of temperance legislation which can be of the slightest value is legislation to prevent the alcoholic from becoming a parent. Let natural selection with its instrument, alcohol, kill out the alcoholic stocks, let man help by legally preventing such stocks from propagating themselves, and you will produce a race which will laugh at alcohol, and can no more be tempted by it than a blind man by a suggestive picture. The actual facts controvert all these propositions in the most convincing fashion.

The Tragedy of the Drinking Workman. In contrast with mere convivial drinking, we have to recognise in this country and in all industrial communities —now including even industrial Italy, which before its industrial epoch was so long quoted as proof of evolution against alcohol—what may be called *industrial drinking,* a habit practically universal amongst what we know as the working classes. It involves the daily consumption of quantities of alcohol considerably greater than those small quantities which, as experiment has proved, can be burnt up within the body. The consequence is that free alcohol circulates as such within the brain. If this process is continued for weeks, months, and years, we find an utter and terrible transformation of "the originally healthy workman who is engaged at a trade that encourages, or, at least, allows, the habit of regular drinking throughout the working day, and who probably goes in also for an occasional convivial bout at the week-end or on special festivals."

This sentence has the key to the whole matter. When we come to study industrial drinking we find that it is *drinking as an aid to work.* In order really to understand it, it would be necessary, first of all, to have made an exhaustive study of the actual manner in which alcohol affects the functions of the nervous system.

The Effect of Alcohol upon Work. But if we study industrial drinking in various occupational groups—as, thanks to Dr. Sullivan, we may now do—we shall soon discover the causes which lead it to vary so widely in different cases. It is most marked in relation

to the lowest forms of labour—that is to say, those forms in which nervous skill is at a minimum and muscular strength the only requirement. The simple explanation of this is that, since alcohol gravely interferes with all kinds of work involving nervous co-ordination and skill, it simply cannot be employed in such work. The dock labourer affords a typical instance of the industrial drinker. His work involves no skill, and is intermittent, demanding "sudden spurts of energy." He can repeat his dose again and again, and until late years most of his employers made arrangements for him to do so. In him there is a terrible development of chronic alcoholism, leading to social disease.

Conspicuously contrasted with the dock labourer is the coal-miner. His work also involves relatively little skill but much purely muscular effort. Plainly, he might be expected to become a chronic alcoholic as a consequence of regular industrial drinking, but this is exactly what we do not find. True, the mining counties are the most drunken counties, but, on the other hand, they display chronic alcoholism and its social results in proportions so small that they rival those of purely agricultural communities, and are below all other industrial groups. The reasons are easily found.

The Coal-miner's Experience. Industrial drinking is rendered impossible in coal-mines. The only chance the man has is to drink before he goes down, and in many mines he is even stopped at the top if he smells of liquor. The consequence is that industrial drinking simply does not exist among coal-miners, a remarkable contrast to their characteristic convivial drunkenness. More interesting still is the fact that the coal-miner is alone amongst working men in his recognition of the worthlessness of alcohol as an aid in labour. The docker can take his dose, appreciate the brief sense of stimulation that follows, and when this yields to the weakening which is the real characteristic of alcohol, he can repeat the dose. The coal-miner down in the pit cannot. Hence he very soon finds that beer does not help him in his work. The consequence is that, whilst in other industries alcohol retains its reputation as an aid in labour, the coal-miner knows that this aid soon gives place to hindrance unless the dose be repeated; and thus, in that industry, and in that alone among purely muscular industries, alcohol has precisely the reputation which it has in the psychological laboratories of Germany and America.

Alcohol and the Mothers of the Race. Of profound importance is industrial drinking amongst women, since suicide, crime, and insanity do not begin to sum up the disastrous consequences of chronic alcoholism amongst the mothers of the race. As Dr. Sullivan points out, the working man's wife, who lives, on the average, perhaps the most laborious and unrelieved life that our community shows, has abundant opportunities for seeking help in alcohol; and "if a knowledge of the effect of alcohol as an industrial excitant has been acquired by the factory girl, it is pretty sure of further development in the married woman." This is especially apt to show itself after the birth of the first child, and is one more factor in explaining the lamentable average difference between the futures of the eldest children and the later children of a working-class family. But it must be recognised that the industrial employment of women as a fact of modern times is of importance not merely because it leads to chronic alcoholism in men, but also because it terribly increases alcoholism amongst men.

A Terrible View of the Employment of Women. Speaking of the reaction of female industrialism on home life, Dr. Sullivan says, in words which cannot be too widely read: "This influence plays a very important part in promoting alcoholism. For the employment of women in the ordinary industrial occupations not only involves a disorganisation of their domestic duties if they are married, but it also interferes with the acquisition of housewifely knowledge during girlhood. The result is that appalling ignorance of everything connected with cookery, with cleanliness, with the management of children, which makes the average wife and mother in the lower working class in this country one of the most helpless and thriftless of beings, and which therefore impels the workman, whose comfort depends on her, not only to spend his free time in the public house, but also tends to make him look to alcohol as a necessary condiment with his tasteless and indigestible diet. Both directly and indirectly, therefore, the employments that withdraw women from domestic pursuits are likely to increase alcoholism and, it may be added, to increase its greatest potency for evil—namely, its influence on the health of the stock."

The relation of alcohol to crime needs no comment here. The latest and widest study of statistics in this country shows that "60 per cent. of graver homicidal offences, and 82 per cent. of assaults are attributable to alcohol." The underlying condition is usually chronic alcoholism and not casual drunkenness. Alcoholism is a potent cause of insanity, and the most recent study of this subject shows, even to those who have long doubted the common opinion, that that opinion is correct. Even when allowance is made for all fallacies, it is no longer possible to deny that insanity is increasing in this country. It must be remembered also that the physical degeneration caused by alcohol leads to insanity and allied forms of social disease. It is thus that alcoholism does most harm to society—not in the generation under study, but in the succeeding generation, "by furnishing recruits to the ranks of the moral imbecile, the epileptic, the prostitute. and the other noxious and parasitic classes."

If Alcohol were Abolished. In short, there is every warrant for the opinion lately expressed by the most distinguished of living physicians, Professor William Osler, of the University of Oxford, who is known everywhere as the possessor of a keen, judicial, and far-sighted mind, that the abolition of alcohol—except, of course, as a drug in certain cases, such as fainting—would at once abolish practically all

the problems which now exercise physicians, philanthropists, and politicians. Fifty years ago, statements like this were made by the unscientific pioneers of temperance, and were laughed at by doctors, politicians, and the public. They are now being continually made by the leaders of medicine and practical psychology everywhere, and the denial of them is merely a proclamation of ignorance, or of something much worse. Thus "the whirligig of Time brings in its revenges."

An Obsolete Manifesto. A recent medical manifesto in favour of alcohol has attracted far more attention than it was worth, and has, significantly enough, resulted in doing more harm than good to the cause of this most accursed thing. Despite the efforts of the promoter, it was not possible to obtain the signature of a single pathologist, a single student of insanity, or of any of the many men whose work has helped to make our scientific knowledge of alcohol; whilst the one authority on drugs who signed the manifesto has already been compelled to explain that its final form is much stronger than that to which he appended his signature. The manifesto contains a series of statements which are not merely unproved, but have been disproved in detail on every point. Complete confirmation of this assertion could only be obtained by a complete study of the whole modern literature of alcohol. The careless quality of the manifesto may be sufficiently estimated, however, by its reference to the "universal belief of civilised mankind" in the dietetic value of alcohol. This so-called universal belief is not shared by the hundreds of millions of Mohammedans, by the hundreds of millions of Buddhists, nor by the Japanese. The assertion as to the value of alcohol in disease has been disproved in detail by comparative observations of the results of the treatment of disease with and without alcohol. Amongst the signatories are one or two practitioners who still do some amount of active work. Not one of them has published any comparative results which prove the value of alcohol, and they may be confidently challenged to do so if they can. The real significance of the manifesto is to be found in the overwhelming weight and authority of the names which have not been appended to it, but have been appended to the statement of facts which contradict it.

Science or Muddle? At this point, with the utmost regret, we must bring our present study of sociology to a close. We have spent nearly the whole of our space upon the discussion of root principles. Our labour has been in vain if these do not demonstrate that every kind of social, political, and international question is not merely capable of treatment as a sociological problem, but that none of these questions can be solved but by one of two methods. The new method is none other than the application of sociological principles to the problem in question. The other is the age-long principle of "muddling through," and permitting natural selection, at appalling cost in time and life and souls, to weed out the bad and establish the good. Contentment with this method assumes that intellect, that great product of natural selection, is of no use in human life. Lastly, we have deliberately chosen the problem of alcoholism as being, in our judgment, the most urgent and momentous and real of the problems which face the thinking man of to-day. But there is a solution for all such problems. Progress is possible, for progress has occurred. "The goal of this great world lies beyond sight," but our children, and we in our children, will see and reach it.

"Our friends are exultations, agonies,
And love, and man's unconquerable mind."

THE MASTER MIND OF SOCIOLOGY

An Introduction to the Study of Herbert Spencer. By Dr. Saleeby

Sooner or later the thinking man in these days, when we all have to "think in evolution," or to no purpose, must feed his mind with the work of the mighty thinker to whom we owe the modern idea of evolution as a universal truth. Now, there are injudicious ways of approaching the work of any thinker, and Spencer is no exception. You cannot pick out at random a volume devoted to the application of certain principles, for instance, until you have previously acquainted yourself with those principles. Yet, again, there are parts of Spencer's work which are for the specialist—parts which only the trained psychologist or biologist can properly appreciate—though he, as a rule, is remarkably ignorant of them. Therefore, I seek to suggest to all concerned the best route of approach to Spencerian thought.

How to Begin. The reader should begin with the best-known and most easily read of all Spencer's works, the "Essay on Education," which was published in 1861. This is admittedly an epoch-making book. It is put into the hands of every State teacher in France; it has been acclaimed by Professor Michael Sadler as the great reformer of the education of girls in our country, and there is no living parent so wise as to be beyond need of its wisdom.

The next most popular work of Spencer's, and, perhaps, the next most readable, except the "Autobiography," is his "Study of Sociology." It is the best known volume of the International Scientific Series. Considerable attention has been paid to this work in the course on Sociology, and no more need be said of it here. Until recently it would have been necessary to counsel the reader to proceed at once from these independent little books to "First Principles," the introductory volume of the "Synthetic Philosophy." Since the publication of the "Autobiography," however, there can be no question that this invaluable book should be read next. The two large volumes contain very much more than the life of the author, and very much more even than a vast number of wise thoughts. They

include, in chronological order, a series of what are practically introductions to the various parts of the "Synthetic Philosophy," including some imaginary reviews of the various earlier volumes, such as hostile but studious critics might have written, if they had thought it worth while to write any. This "Autobiography" is one of those books which are not for an age but for all time. If it were not a great contribution to human thought it would live as, perhaps, the most honest and complete self-revelation in literature —and what a self to reveal! Special attention should be paid to the wonderful last chapter, called "Reflections."

"First Principles." After this the student must attack "First Principles." We are trying to make his part easy, and we recommend that he should read, to begin with, the first and the last chapters of Part I. on the Unknowable. This section contains Spencer's ultimate philosophy, but, as any student of philosophy will readily understand, stands quite apart from the proximate or scientific philosophy which was his great life-work. That is introduced in Part II. of this work, which, though it contains hard pages, must be read from end to end. It is not a large book, and is the central book of the thought of the nineteenth century.

In our opinion, the student would make a great mistake if, after this, he proceeded *seriatim* to the "Principles of Biology and Psychology." On the contrary, let him turn aside to Volume I. of the collected Essays, and let him dip into this as he pleases. It will probably persuade him to return to "First Principles."

Spencer's Greatest Book. Even now, let him leave the more special volumes aside, and let him pass on at once to what, for practical value in human life—value independent of any place or time—is undoubtedly Spencer's greatest work—*viz.*, "The Data of Ethics," which is the first and most important part of "The Principles of Ethics." This, like "First Principles," has been republished in a very attractive form since the author's death. The student, if he is wise, will follow the direction in which his studies lead him, but it may be guessed that, after reading the "Data of Ethics" he will pass on to the great study of Justice, forming his own opinions, no doubt, as to the individualism and the doctrine of the "Limits of State-Duties," so forcibly enunciated at the end of that volume. After this, the student will doubtless pass to the "Principles of Sociology," and it is difficult to name any part of that great work that he will not feel bound to study.

The "Biology" and "Psychology." As for the "Biology" and the "Psychology," we have no intention of under-estimating their worth. Classics they both are and will remain; but they are long and difficult, and they do not have the same immediate relation as the rest of Spencer's works to the questions which must concern every thinking man. Therefore, except for the professional student, we should advise a return to the volumes already named. It is not exactly possible to suck them dry at the first attempt, nor at the second. The first two named may be picked up in any spare moment; they are as easy to read as a novel. Chapters I. and V. of "First Principles" must be re-read whenever one feels oneself losing hold of the great principle of tolerance, whilst the "Data of Ethics" must be returned to again and again. It is this volume that is the crown of all Spencer's work, for, as he tells us himself, from the year 1842 onwards his "ultimate purpose, lying behind all proximate purposes, has been that of finding for the principles of right and wrong, in conduct at large, a scientific basis."

The Way Not to Read Spencer. The student who would ask whether or not Spencer succeeded is answered in that volume, and if any doubts remain as to the epoch which it initiates, let him refer to the works of previous moralists. The reader will understand that the sequence named is only submitted as a suggestion. The serious student may begin anywhere and then follow his own needs. But, unfortunately it is not everyone who will give time and care to what makes no intermediate appeal, especially if a task of great length is proposed to him. Thus many have made a single attempt to acquaint themselves with the Synthetic Philosophy and have abandoned it. The project of reading the philosophy from beginning to end as the first step towards its appreciation is certain to fail. The reader must first convince himself, by personal experiment, that such a course is worthy of his time and labour, and this he can do only by turning first to the salient portions which cannot fail to reward him at once and encourage him to proceed.

In his small book, "Evolution the Master-key," the present writer has attempted to introduce the works of Herbert Spencer to the twentieth century reader in the light of the latest knowledge that we now possess.

HERBERT SPENCER'S WORKS

Published by Williams & Norgate

"An Autobiography," 2 vols., 28s., net.

A System of Synthetic Philosophy. "First Principles," 7s. 6d.; "Principles of Biology," 2 vols., 36s.; "Principles of Psychology," 2 vols., 36s.; "Principles of Sociology," Vol. I., 21s.; Vol. II., 18s.; Vol. III., 16s.; "Principles of Ethics," Vol. I., 15s.; Vol. II., 12s. 6d.; "Justice" (separately), 6s.

Other works. "The Study of Sociology," 10s. 6d.; "Education," popular edition, 2s. 6d.; "Essays," 3 vols. 10s. per vol.; "Social Statics & Man *v.* State," in one vol., 10s.; "The Man *v.* The State" (separately), 1s.; "Facts and Comments," 6s.; "Various Fragments," 6s.; "Reasons for Dissenting from the Philosophy of M. Comte," 6d.; "A Rejoinder to Professor Weismann," 6d.; "Weismannism Once More," 6d.; "Against the Metric System," 3d.

Descriptive Sociology. "English," 18s.; "Ancient American Races," 16s.; "Lowest Races, Negritos, Polynesians," 18s.; "African Races," 16s.; "Asiatic Races," 18s.; "American Races," 18s.; "Hebrews and Phœnicians," 21s.; "French," 30s.

Sociology *concluded; followed by* Logic

Group 8 **DESIGN** 1 Following DRAWING from page 5698	# THE PRINCIPLES OF DESIGN **Draughtsmanship and Study. Tradition and Nature. Symmetry, Balance, Repetition, Congruity, and Contrast. Line and Curve. Conventional Plant-forms**

By P. G. KONODY

IT is impossible for anyone to design good ornament without having first acquired a mastery of the art of drawing. A dramatist cannot write a successful play without a sound knowledge of stagecraft, and in the same way good draughtsmanship is essential to a designer, for it is the scaffolding on which all his work is built. Intelligence, imagination, observation, are all necessary qualities, but though a student may overflow with ideas, he will never be able to give them expression unless he has become an accomplished draughtsman.

In the second place, every opportunity should be taken for studying the masterpieces of past periods. It is a mistake to suppose that inborn originality and natural genius are all sufficient in themselves, and need no nutriment of study. Education and knowledge are the only true foundation of strength and confidence. " Design," wrote Ruskin, " is not the offspring of idle fancy ; it is the studied results of accumulative observation and delightful habit."

The Help of Museums and Churches. The student should always carry his sketchbook in readiness to note a characteristic piece of design or a beautiful detail of ornament. The patterns and schemes of decoration in use at different periods for buildings, furniture, domestic utensils, personal ornaments, and so forth, should form subjects for observation. Particular attention should be paid to the way in which tools, materials, and methods of work have influenced the treatment of ornament among different nations at various periods in the world's history. In any old church will be found scores of objects of beauty and interest, architectural features, sculptured monuments, carved

1. GREEK ANTHEMION, OR HONEYSUCKLE ORNAMENT

woodwork, work in iron, gold, silver and brass, windows, mosaic floors, gold and silver vessels, all of them full of inspiration and suggestion.

The Value of a Notebook. Above all, the student should further his studies by working in museums, which, to the intelligent, are not all the " cold tombs " that a French writer named them. The study of historic ornament is not to be despised, and much may be learned from the primitive ornament of savage tribes, with its zigzag [2] and interlacing patterns, its rude adaptation of human and bird forms. The history of design is one of gradual development, from primitive patterns to the perfect art of Greece, with its sculptured friezes and carved capitals, its splendid vases and metal ornaments ; to the ivories and enamels of mediæval days ; to all the glories of the Renaissance, with its

2. POLYNESIAN ZIGZAG ORNAMENT

stained glass, its tapestries and embroideries, its furniture, its perfect finish in gold and silver work, and in all objects of use and costume. All periods and all kinds of art have their lessons to teach, lessons that should always be noted. For to the designer a well-stored notebook is as important as a well-stored memory. Captain Cuttle's " When found, make a note of " is an excellent maxim, perhaps even better expressed by an old essayist, who wrote : " What you observe of worth, take notes of ; for the leaves of your books are easier turned over than the leaves of your memory."

Tradition and Nature. While the would-be designer should be steeped in tradition, and take every opportunity for the study of ancient art, he must clearly understand that the knowledge thus acquired must not be used as a means of paraphrasing and reproducing old themes, but as a sure foundation on which his creative faculty can base and develop new ideas. There are, of course, certain forms and ornaments that centuries of use and slow development have brought to stereotyped perfection that must be accepted and constantly adapted without thought of alteration or improvement. At the same time there is always scope for modern originality. The Greeks brought the conventional lotus, honeysuckle [1] and acanthus ornament to absolute perfection ; but it must be remembered that the *principle* of this ornament may be applied to hundreds of other plants and flowers, and that modern civilisation has produced a hundred fresh directions in which design and ornament can be employed.

Nature the Art of God. The history of design in the industrial arts is an interesting study in evolution. Rude primeval models are gradually improved to meet the varied wants and necessities of mankind in the progress of civilisation. All the familiar and elaborate forms

in architecture, furniture, textiles and so forth have been developed from elementary beginnings to suit the changing conditions of society. But the more one studies historic and traditional ornament, the more apparent it is that all design is based on Nature. In the first place, all objects of design, from the wonders of architecture down to the most trifling personal ornament, are influenced and modified by the natural material, be it wood, stone, iron, gold, silk, wool, in which they are wrought. In the second place, it will be observed that the basis of all design lies in the lines and forms of Nature, in its structure and growth, as displayed in the human form and in animals, trees, shells, birds, waves, etc. "Art," wrote Sir Thomas Brown, "is the perfection of Nature. In brief, all things are artificial; for Nature is the art of God."

Symmetry and Balance. From the study of Nature and of tradition, and from the comparison of all that is most beautiful in Nature, and in applied art, certain fixed laws or principles may be deduced, which govern all sound design. One of the first is that of symmetry and balance. By symmetry is understood the placing of similar masses or lines on either side of a common axis so as to repeat and answer to one another. It is the simplest means of producing ornament, for it consists merely in the doubling of some ornamental form. Absolute symmetry is rare in Nature, though in most of Nature's work there is a suggestion of it. A front view of the human figure, or of a butterfly with spread wings, gives an example of near approach to absolute symmetry. While perfect symmetry is rare in Nature one of Nature's most important laws is that of balance, the arrangement of dissimilar masses or lines so as to produce an impression of harmony. A tree is never symmetrical, yet it will be seen that the branches on one side of the trunk balance those on the other, and the same truth applies to the veins in a leaf. In filling a defined space with design, if you place a mass of form or colour on one side of a centre line, the need will instantly be felt of balancing it by a corresponding mass, not necessarily identical.

3. MOSAIC PATTERN IN THE BAPTISTERY AT FLORENCE, SHOWING THE PRINCIPLE OF COUNTERCHANGE

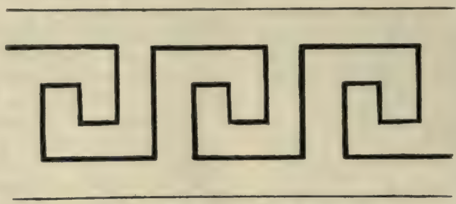
Repetition and Rhythm. Another great principle in design is that of repetition. The use of a sequence of corresponding units produces at once a harmonious effect. In the borders of ancient and classical art, in the anthemion and egg-and-dart ornaments, for instance, a pleasing and rhythmical quality is produced by the recurrence of some simple form. It will be found that the more abstract a form is the better it will bear repetition, and that it becomes less suitable the more closely it approaches imitation of Nature. The realistic repetition of a flower or group of flowers is incorrect and displeasing to the eye, for the reason that in each natural form there are varying modifications and accidental details, which in Nature are never identically repeated. In an avenue of trees, for instance, no tree exactly repeats another. Directly repetition is applied to anything beyond ornament it threatens monotony, as in the case of a succession of windows or a row of railings, all equidistant and uniform. This monotony, however, may readily be broken by the introduction of a larger window or a more important post at regularly recurring intervals, and the result is then a pleasing rhythm.

Radiation. Radiation is the law whereby groups of lines diverging from a common centre suggest common origin or growth. In Nature, the principle may be noted in the human hand, in plants and trees, the feathers of birds, the tail of the peacock, the shell, the water of a fountain, or the rays of the sun, the frost flowers on a window-pane. It follows that radiation when applied to design gives at once a natural vitality and vigour. It suggests constructive strength as well as lightness and perfection of balance, as can be seen in the Corinthian capital, in the vaulting of Gothic architecture, in the piers of a bridge, in the folds of drapery, in the wheel, and in the homely fan.

Congruity. The principles of congruity imply the harmonious relation between the different parts of an object, or between the complete object and its surroundings. Styles of different periods must never be employed so as to produce a harsh discord. The principle is one too often abused in the clashing furniture of modern houses, where the Jacobean and Louis Quatorze periods, the Chippendale style, and that of the Gothic revival, often meet in haphazard union. In our cathedrals, where Norman architecture runs into Early English, and Early English is joined to Decorated and Perpendicular, there is always the connecting idea of gradual growth and progress in transitional stages. For an example, however, of the utterly incongruous in architecture, one may instance the church of St. John, Horsleydown (on the south side of the Thames, near the Tower Bridge), where a debased Corinthian column is used as a spire, the very essence of a column being the idea of support; used, too, on a building of the Renaissance style. Another example is the classical doorway, a so-called restoration, added by Sir Christopher Wren to the Norman work of the north transept of Ely Cathedral.

Contrast. One of Nature's most obvious laws is that of contrast, as exemplified in day and

night, summer and winter, male and female, flower and leaf, land and sea. In the markings of animals, the plumage of birds, the colouring of flowers, it will be observed that constant beauty is produced by contrast in form and colour. In design, therefore, contrast is one of the means of obtaining freshness and variety. What makes the beauty of a Corinthian capital is largely its contrast with the simple column beneath it. Any drawing in pure black and white shows the value of contrast. One of the most striking instances of the universal device of contrast is symmetry, of which we have spoken, where the design on one side of a common axis is reversed and contrasted with the other side. By means of colour, or by light and shade, contrast may be infinitely developed. The egg-and-tongue [8] and the anthemion [1] patterns show contrast of black against white and of straight line opposed to curve. Another example of contrast is the chequer or chessboard pattern, one of the oldest and most universal of ornaments.



4. GREEK FRET ORNAMENT

Counterchange. A further application of contrast is the use of counterchange, by which a pattern is designed so that the ornament forms an exact counterpart of the ground, and vice versâ [3]. Counterchange was largely employed in Arabian and Saracenic decoration, and in Spanish and Italian textiles of the seventeenth and eighteenth centuries. In a way it is a direct infringement of the laws governing proportion, for a design that leaves one in doubt as to what is ground and what ornament is more puzzling than satisfactory. In a simple geometrical diaper, however, such as a chessboard, or a plain mosaic floor, this fault is not apparent, and counterchange is a useful form of decoration. In a more complicated pattern it is apt to irritate the eye.

5. EGYPTIAN BORDER ORNAMENT, SHOWING WAVE PATTERN

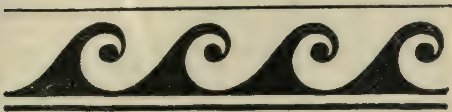
6. DOUBLE GUILLOCHE PATTERN

Unity and Subordination. A successful application of the other laws and principles of ornament will help to produce unity. Unity of style and decorative subordination are essential elements in good design. Every detail should co-operate to the production of a single effect, dignity and beauty being impossible in any work of art without perfect uniformity of idea and treatment. In furnishing a room, for instance, wallpaper, carpet, furniture, should form a harmonious concord of colour and design. Carpets and wallpapers should be flat in treatment, subdued and quiet in colour, for they are a subordinate background to pictures and furniture. They must not form a picture in themselves, attracting the eye by vivid contrast of colour or by pronounced pattern, but must serve, like the background in a picture, to relieve and heighten the central point of interest. So also in any complex piece of ornament one part should be emphasised as the most important, and the other parts should lead up to it, echoing, perhaps, in a minor key the main motive. An ornamental handle or spout on a vessel should never seem to be an added afterthought, but a portion of the original scheme, an integral part of the whole. A common instance of want of unity occurs when the stem and leaves in a plant design are treated in a formal conventional style, and then finished with absolutely realistic flowers. A good rule for the designer is that whatever element of decoration he employs, be it vegetable, animal, or human forms, and whatever colour he uses, it should be repeated throughout his whole composition.

The Straight Line. So far we have been dealing mainly with the principles and theories of design, and it remains to give some suggestions for their practical application. In the first place, it must be noted that the three essentials of design are line, form, and space. Line, the basis of all ornament, is used to give the framework of the design, to define the forms, and to express the lines of structure. Form is required to give substance, mass, and variety, as well as to express contrast in colour and relief. In actual adaptation both of these will be found subservient to space, for it is obvious in design that line and form are always controlled by the fact of their having to fill a definite enclosing space.

The student should pay careful attention to the expressiveness of line, noting how vertical lines (the lines of a tree or column) express support; how horizontal lines (the lines of the ground or horizon) suggest stillness and stability; while undulating lines or curves (the lines of the waves or of wind-swept trees) indicate movement and natural growth. The elementary stage of design demands the noting of the number of patterns that may be evolved from the use of

the straight line. All the various regular geometrical forms—the triangle, square, rectangle, diamond, lozenge, star, and every kind of polygon—are integral parts of ornament, used largely as constructive bases in pattern designing. By following the principle of repetition, ornament can be obtained by straight lines in all manner of patterns, such as the *zigzag*, so



7. GREEK WAVE ORNAMENT

characteristic of Polynesian ornament [2], or in the *fret* [4], employed largely by the ancient Greeks.

The Line and the Curve. In Nature the curve is essentially the " line of beauty," and in design the repetition of a curved form at once produces an effect pleasing to the eye. The *simple meander*, the *guilloche*, the *spiral*, and the *scroll* form effective borders [4 and 6]. The Greeks, bringing convention to bear on Nature, used the blue waves of the Ægean Sea as the motif of their charming wave pattern [5 and 7]. Their *anthemion*, or honeysuckle ornament [1], so frequently used for the decoration of vases, remains one of the finest examples of border ornament. The curves of the acanthus were wonderfully adapted in the capital of the Corinthian column.

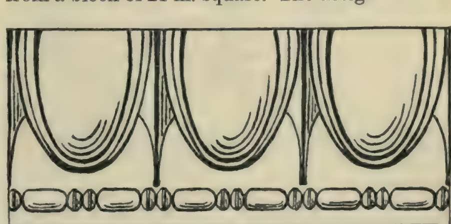
The combination of the straight line and the curve used in repetition supplies an endless variety of ornament for borders or mouldings. The anthemion design was frequently used on vases with double lines or a fret pattern beneath it. The *egg-and-tongue moulding* [8] (figure shows the " ovolo " along with the astragalus or bead moulding) is a fine combination of the straight line and the curve. These Greek examples, all admirably adapted to horizontal extension, have held their own from the earliest times as types of perfect design. The line and the curve also produce systems of pattern adapted for indefinite extension both vertically and horizontally. They must be repeated on a geometrical rectangular basis. A repetition in two directions of squares (as on a chessboard) or of diamonds, or circles (single or interlacing), or combinations of these forms, produces what is called a *diaper*. On this diaper basis may be built any superstructure of floral design.

Plant Form in Design. Having gained the power of expressing ornament by means of straight lines and curves, the next step is to make use of plant form. The designer is more dependent on plants and flowers as a material for ornament than anything else in Nature's domain. The human figure and animal forms are used incidentally, but plant ornament is the basis of all design.

The first thing is to make a careful and scientific drawing of the plant, exactly as it appears in Nature, dwelling on all the varieties of form and surface, of light and shade. Now, even when starting to draw a plant with a purely graphic purpose, you will find that, consciously or unconsciously, you are beginning to design. The selection of the point of view, the arrangement of your subject on the paper, are both elements of decoration. Having completed a careful study, the next step is to notice the governing lines in the drawing, to analyse the foliage and flowers with a view to the selection of ornamental forms to be derived from them. Your first drawing should be merely imitative, with elements of design ; your second, in its selection, its rejection, its arrangement, should be design pure and simple. The second drawing should show the plant displayed and flattered with seed-pods, birds, flowers, and leaves treated as motives for decorative ornament.

In Nature there are all kinds of excrescences and accidental irregularities ; but the designer must no longer look at his plant with the eye of a botanist. The adaptation of plant form does not mean the twisting and arranging of the plant to fit a required space. The artist must absorb the natural beauties of floral growth, and express them not by means of a naturalistic transcript, but by the abstraction and selection of their grace in line and form. To give a merely imitative rendering of natural forms is in most of its applications one of the falsest and most debased styles of ornament.

The Repeat in Wallpaper. It was pointed out above that repetition was an essential principle of ornament in the handicrafts of antiquity. To-day it is even more essential, owing to the demands of modern machinery. Machinery must necessarily reproduce a design by constant repetition, and whether a design be printed, stamped, or woven, the " repeat " is necessary. It is impossible here to enter into the varied requirements of different trades, but it may be well to consider the repeat in relation to one of the most important—that of the printing of wallpapers. Wallpaper in our country is printed from a block of 21 in. square. The designer has to



8. GREEK EGG-AND-TONGUE (OVOLO) AND HEAD (ASTRAGAL) ORNAMENT

construct on this a pattern pleasing in form and colour, which will repeat all over the surface of a wall without flaw, and without losing its interest. The block may in itself contain one or more repeats. The repeat is extended in a vertical direction by successive printings of the block ; and in a lateral direction the extension is caused by the hanging of lengths of paper side by side.

Continued

Group 13 COMMERCIAL GEOGRAPHY 11	THE TRADE OF EUROPE
Continued from page 5710	The Western Mediterranean Business and Trade. Economic Divisions and Trade of France. Belgian, Dutch, Swiss, and German Trade Conditions

By Dr. A. J. HERBERTSON and F. D. HERBERTSON

THE Mediterranean climate and products have received special attention in previous articles. [See especially pages 2230–4.] The peculiarity of rain falling in the winter half of year is of great economic significance.

The economic development of the Mediterranean countries, however, depends partly on the configuration and position of the country, but even more on the stage of advancement of the population. In this long settled area can be traced the rise and fall of peoples better than elsewhere, and the effects, economic and social, of different economic regimes.

Economic Decay and Advance in the Mediterranean Countries. Asia Minor, once the most prosperous part of the Mediterranean basin, is now the least so. The decay has been largely due to the neglect of roads and irrigation, the two ways which formerly permitted the circulation both of commodities and of the fertilising streams to the fields. The substitution of a pastoral for an agricultural civilisation leads inevitably to a decrease in the food-producing possibilities of the land as well as to the diminution of its trading capacity, and the decay alike of its commercial routes and of the government which protects a settled population.

Egypt, on the other hand, has progressed enormously in recent years, through the security afforded by the reform of its government and the improvement of its irrigation.

Turkish and Egyptian Trade Compared. The trade figures of the Turkish Empire are, unfortunately, old and unreliable. The exports probably amount to £15,000,000 and the imports to about £23,000,000; but by some the imports and exports are both estimated at between £20,000,000 and £25,000,000. The chief exports are silk, grapes, mohair, cereals, especially barley, opium, and valonia; and the chief imports, textiles, sugar, cereals, and flour.

Compare with these the returns from Egypt for 1905 in Egyptian money (£1 E = £1 0s. 6¼d.).

Exports	£(E)	Imports	£(E)
Raw cotton ..	15,806,000	Textiles ..	6,053,000
Cereals and vegetables ..	2,730,000	Metals and manufactures	2,837,000
Drugs	630,000	Cereals and vegetables ..	2,793,000
Animals and products (including hides)	318,000	Wood and coal	2,679,000
Total of all kinds ..	19,484,000	Total of all kinds ..	14,362,000

Perhaps no more telling proof of the change in Egypt can be found than a comparison of Egyptian figures for 1905 with those of ten years earlier.

Exports	1895	Imports	1895
Raw cotton ..	9,532,000	Textiles ..	2,583,000
Cereals and vegetables ..	2,273,000	Metals and manufactures	857,000
Miscellaneous ..	827,000	Cereals and vegetables ..	779,000
		Wood and coal	1,074,000
		Miscellaneous ..	3,097,000
Total of all kinds ..	12,632,000	Total of all kinds ..	8,390,000

Greece. With its mountains and narrow plains, Greece is not suited to great agricultural development. Currants and iron ore are the chief exports, with wines and oil secondary ones. One-third of the imports are agricultural products, and one-seventh textiles. By far the largest trade is with Britain.

The Western Mediterranean Lands. The Western lands are much more advanced, and present a considerable economic contrast to those of the Eastern basin. The lowlands are greater in area, and are more carefully cultivated. Wine and oil form an even more important part of their products. There is little industrial development, except in Northern Italy, Southern France, and round Barcelona, in Spain. Portuguese, Algerian, and Tunisian statistics are more comparable with those of the Eastern lands. Algerian, Moroccan, and Tunisian trade is still largely agricultural. Over 30 per cent. of the exports from Tunis, which are valued at 77,000,000 francs, consist of cereals, over 12 per cent. of olive oil, while phosphates, zinc, and lead ores amount to over 21 per cent. Textiles, iron goods, flour, sugar, and coal are the chief imports. The bulk of the trade is with France. Next come Algeria, Italy, and Britain.

Algerian and Moroccan Trade. Algerian trade is much larger. The exports are worth over 272,000,000 francs. They resemble those of Tunis in many respects, but the proportion of cereals is much smaller (only 10½ per cent.), while wine is an important product (35 per cent.). Live animals account for 12 per cent., and hides and wool for 6 per cent. Phosphates are not quite so valuable as in Tunis, but iron and zinc ores are worth nearly 5 per cent. of the exports. The imports resemble those of Tunis.

Over 80 per cent. of the total trade is with France, Britain coming next with little over 3 per cent.; but Belgium takes nearly as much from Algeria as we do. Germany and Italy both figure more prominently in the export than in the import columns, while Brazil, Morocco, Spain, and even the United States are more prominent in the import columns.

Moroccan trade is comparatively small. Products such as eggs, almonds, wool, wax, birdseed, and beans, which require no great care to produce, are exchanged for cottons, sugar, and tea.

Portuguese Trade. Nearly half the country of Portugal is waste land, and one-tenth is under fruit trees and shrubs, of which one-fifth is vineyards.

Wine (over one-half of it port) is by far the most important export (nearly one-third), and cork comes next (one-eighth). Fruits, fish (especially tinned sardines), cotton, and copper ore are other important exports; 26 per cent. go to Britain, 18 per cent. to Spain, 17 per cent. to Brazil and the Portuguese colonies. Britain obtains 22½ per cent. of its wine from Portugal. Cotton and cottons, wool and woollens, coal, iron, and machinery, codfish, wheat, sugar, wood, and livestock are among the chief imports—30 per cent. come from Britain, 17 per cent. from Germany, 10 per cent. from the United States of America, 9 per cent. from France, and 9 per cent. from Spain.

The position of Lisbon makes it an important entrepôt centre, to and from which is carried produce from South America, more particularly from Brazil and from the Portuguese colonies.

Economic Divisions of Spain. There are four great areas in Spain: (1) The forested and mineral mountains of the north; (2) the pasture lands of the Meseta and the Ebro valley, which are only here and there cultivated; (3) the mineral zone of the Sierra Morena and Sierra Nevada in the south; and (4) the fertile plains of Andalusia and the terraced hillsides of the coastal regions of the Mediterranean. In this region is Barcelona, the chief manufacturing centre, noted for its cottons, silks, woollens, and paper (made largely from esparto grass).

Spain has two outlets: (1) By the Mediterranean to the east and south and west; and (2) by the Atlantic to the west and north. The internal routes are poor and inadequate, and this greatly hampers Spanish economic development. One-third of Spain is cultivated, one-fifth produces fruits, and another fifth is under grass, while nearly 4 per cent. consists of vineyards.

Spanish Exports and Imports. From the north of Spain iron and iron ore and partially manufactured iron are exported, especially from Bilbao, where there are many ironworks. Some zinc and cobalt are also exported from this district. The southern mineral zone yields much copper (exported from Huelva), silver, silver-lead, lead and mercury (Almaden). Metals, minerals, and their manufactures amount to 34 per cent. of the total value of exports—874,000,000 pesetas (say, 33⅓ pesetas = £1).

The wine, grapes, raisins, oranges, figs, olives (and olive oil) and other fruits shipped from the Mediterranean ports and Cadiz amount to nearly 40 per cent. of the exports.

Spanish imports include alimentary products, such as grains to a percentage of 20 per cent. of the total of 845,000,000 pesetas in 1904; while raw cotton, or cotton goods, formed 13 per cent. Coal, iron goods, and machinery form an important group of imports.

Spanish trade relations are worth analysing. The eight States with the greatest trade are.

Country	Exports to	Imports from
	1,000 of pesetas	1,000 of pesetas
United Kingdom	308,105	172,278
France	189,593	122,512
German Empire	44,662	92,890
United States ..	27,498	102,095
Portugal	35,618	38,462
Belgium	27,212	34,570
Italy	39,661	25,016
Cuba	80,401	4,523

Britain, France, and Cuba take more exports than other countries. To Britain and France are sent much iron ore, wine and fruits; to Cuba, wines and manufactured articles. Britain, France, the United States, and the German Empire supply most of Spanish imports, mainly manufactured articles, with cereals and cotton, in addition, from United States.

Economic Divisions of Italy. Italy is mainly agricultural, and over 70 per cent. of its surface is productive. Wheat is grown on 17 per cent. of the surface and vines on 14 per cent., the maize fields and olive groves being next in importance. On the hill slopes mulberry and other trees flourish. On the Alpine meadows and grassy flood plains many cattle are kept, and cheesemaking is important.

Apulia, which produces hard wheat from which macaroni is made, in the east is divided by the Apennines from the fertile flood plains and hill slopes of the west, while the Sicilian region and the Neapolitan Campagna, with their lemon, orange, and olive groves and vineyards, and Tuscany, with fewer oranges and more vines and olives are the most productive. Except sulphur from Etna, marble from Carrara, iron ore from Elba, and some iron, silver, lead, and zinc from Sardinia, the produce is mainly fruits and wine and olive oil, with straw plait, and artistic articles for tourists.

Northern Italy is shut in by mountains. The irrigated northern plains are cold in winter, very warm in summer, so that not only wheat and maize, but even rice is grown. The perennial streams yield abundant water supply for the electric power which is so important in an area where there is no coal. The chief manufacture is silk, the silkworms being fed on the mulberry leaves, and the cocoons unwound in many villages. The chief centres are Como, Brescia, Bergamo at the opening of Alpine valleys, and Milan, the great city of the plain. Engineering works have become of great importance at Milan, Turin, and other centres.

The outlets of this northern region to the sea are by Genoa, reached by fairly easy passes, and, to a less degree, through Venice. The Alpine tunnels connect it with the colder lands of Central and Western Europe, to which its richer produce is sent.

Italian Exports and Imports. Of Italian exports, raw silk is by far the most important, forming 26 per cent. of the total of nearly 1,600,000,000 lire (25 lire = £1). Cotton and silk, olive oil, flax and hemp, sulphur, eggs and wine come next. Switzerland, the German Empire, France, and the United States are the chief customers; then come Austria-Hungary, Britain, and the Argentine Republic, to which so many Italians have emigrated.

Of Italian imports raw cotton is the chief, 12 per cent. of a total of over 1,900,000,000 lire; coal and coke in a coal-less land naturally come next. Cereals to the value of over 125,000,000 lire are brought into the country, and the local raw silk is supplemented by over 100,000,000 lire worth, obtained mainly from the Far East. Ironwork and machinery, timber, wool, hides, and cured fish are among the other important imports.

Of these imports 17 per cent. come from Britain, which sends far more goods to Italy than it receives from it. The German Empire, United States, France, Austria-Hungary and Russia are the next most important sources of import.

The position of Italy is a favourable one for commerce. In touch through the Alpine tunnels with the Great Powers of Continental Europe, it is connected with the Atlantic and Indian oceans by the Strait of Gibraltar and the Suez Canal. Though it cannot be expected to attain

the preponderant part which it played in mediæval commerce, its economic development and commercial expansion are both assured.

Economic Divisions of France. The three mountain areas of the Pyrenees, Central Plateau and Alps are of small economic importance compared with the three lowland areas, southern, western and northern, each of which touches a different sea. [See pages 1681–4, where a full description will be found.] Nearly 42 per cent. of working people are farmers or foresters, 30 per cent. are engaged in manufacturing industries, 12 per cent. in trade and transport.

The southern lowlands of Languedoc and Provence face the Mediterranean and belong to Mediterranean type of country. Wheat and maize, and lucerne are grown in the fields, but olive groves and vineyards are more important, and on the hillsides the mulberry flourishes and silkworms are reared. Silk weaving is carried on chiefly at Lyon on the Rhone, near the St. Etienne coalfield, where St. Etienne is noted for silk ribbons, but spinning is common through all the southern region of France. Marseille is famous for soap, candles, and other works depending on copra, palm oil, and other tropical produce brought by its fleet of merchant ships from warmer lands. More wine is produced here than in any other division of France, and much of it is shipped at Cette.

The Western Lowlands and the Central Highlands. The western lowlands of the Garonne basin produce much wine (clarets) especially round the Gironde estuary, where Bordeaux is the port and chief commercial centre. Maize is still an important cereal. Throughout this area fruit-preserving, especially of plums, is important. At Bordeaux colonial produce, especially sugar, is prepared for the market. The central highlands support large flocks of sheep and herds of cattle, but agriculture is important in the fertile plains of the Loire and the Allier. Vineyards are found all round the margins on terraced hillsides facing the south, especially on the limestone heights of the Côte d'Or, which link the Central Plateau to the Vosges. Here the wines of Burgundy are made. The chief centres are Dijon, Beaune and Macon. Small coal and iron fields round the margin give rise to numerous small industrial centres. The metal works of Le Creuzot and St. Etienne are the most important, but minor smelting and machine-making centres are in the Nivernais, Alais, and Rouergue. Woollens are important in Languedoc, round Bédarieux, and porcelains round Limoges.

Northern and Eastern France. The northern lowlands are mainly in the Seine basin, and they may be considered to extend westwards down the Loire to the Bay of Biscay, northwards through the low hills of Picardy and Artois, and eastwards across the heights bordering the Meuse and the Moselle. This is the centre of wheat and beet-growing. Apple orchards and cider become important in the north. Vineyards and wines, including sparkling wines are found in the south, in the Champagne and Loire districts.

There are four great industrial areas in Northern and Eastern France: (1) The Parisian district, making *objets de luxe*, pottery, paper, etc.; (2) the lower Seine, where English coal, American cotton, and Argentine wool can be brought cheaply to Rouen (cotton) and Elbeuf (woollens); (3) the eastern industrial area supplied with coal from the Saar fields, making iron and steel and cotton; (4) the northern coalfield with its cottons, linens, and woollens made at Lille, Tourcoing, Roubaix, Valenciennes, Reims, and other centres, numerous iron and steel works, and many sugar factories, most numerous in the western margin, where most sugar beet is grown. Dunkirk is the outlet for the region, which is intersected by a good canal system running to Paris.

French Trade. The table given below shows generally the chief divisions of French commerce and their values during the past four years (a franc = 9¾).

From such a table we notice the variations from year to year, which it is not possible to analyse in the brief space at our disposal here. This, however, warns us to use mean values as much as possible. Further, we notice how France exports almost as much food products as it imports, and in this respect it differs from other industrial countries of Western Europe. A third point is that both imports and exports of manufactured goods are increasing, a sign of healthy development.

	Imports (1,000,000 francs)				Exports (1,000,000 francs)			
	1902	1903	1904	1905	1902	1903	1904	1905
Food products ..	818	961	817	800	707	663	693	778
Raw products ..	2,799	3,021	2,853	3,026	1,170	1,176	1,221	1,261
Manufactured goods	777	819	832	847	2,375	2,413	2,537	2,722
Total	4,394	4,801	4,502	4,673	4,252	4,252	4,451	4,761

French exports in 1904 consisted of textiles, 16 per cent.: silk, 6·4 per cent.; woollens, 4·8 per cent.; and cottons, 4·8 per cent., formed the most important class of exports. The fine French workmanship and taste ensure a market for highly priced goods. Raw wool and yarn, 6 per cent., raw silk and yarn, 3 per cent., are both important. Wine, 4·8 per cent., is the chief alimentary product, small ware, 4·4 per cent., leather, linen, and metal goods, skins and furs, and chemical products (each about 2½ per cent.) come next.

Britain takes 27 per cent. of these exports (largely silk and woollen goods, wine, sugar, butter, leather, carriages, clothes and cotton goods), Belgium 17 per cent., Germany 14 per cent., Algeria 7½ per cent., the United States and Switzerland each 7 per cent. The United Kingdom is thus by far the best customer of France.

French Imports. Raw wool, 8½ per cent., raw cotton, 7½ per cent., and raw silk, 7 per cent., are the chief imports. The lack of coal is made up by importation of coal and coke, in decreasing quantities, but still amounting to 5 per cent of the total imports. Oil seeds, 4½ per cent., timber, 3½ per cent., hides and furs, 3 per cent., and cereals, 2¼ per cent., are the next items.

The United Kingdom and the United States have the greatest share in supplying French needs, each being 12½ per cent. From Britain come coal, woollen and cotton goods, machinery, metals, and chemicals. Then come Germany, 10 per cent., Belgium and Russia, each over 6½ per cent., Algeria and Argentina, each 5 per cent.

British trade is thus by far the most important for France, then that of Germany and the United States, showing that countries well developed economically have very large trade with each other.

The French transit trade is considerable. The general exports for 1904 were worth 5,744,500,000 francs, those of French produce, 4,451,000,000, a difference of 1,293,500,000, or 22½ per cent. of the export trade. The favourable position of France in the Mediterranean and Atlantic and its contiguity to the great European states explain this trade.

The Belgian Industrial Area. The Belgian industrial area is a continuation of that of Northern France. It is especially famous for linen made from local and imported flax (at Ghent, Tournai, and Courtrai), woollens (at Verviers) from Ardennes, as well as imported wool, and round Liège for steel and engineering works near the rich ironfields of the Ardennes and the zinc of Vieille Montagne. Lace is made at several towns (Mechlin, Brussels), while at Antwerp sugar is refined and beer and spirits are made.

Belgian Exports and Imports. The trade of Belgium presents many contrasts with that of France. It has not the same variety of agricultural produce, and the country is not nearly as self supporting. Its rich coalfields, on the other hand, yield more than enough for home use. Its transit trade is even greater than that of France, and forms 43 per cent of the export trade of 3,849,000,000 francs.

Antwerp is one of the great wheat ports of the world. The wheat is distributed by rail and also by water. It is towed in barges up the Rhine, even as high as up to Strassburg. Some may even be sent to Strassburg by such a roundabout way as by the Meuse, and the Rhine and Main Canal at a higher cost, and taking much longer time. As it saves the Strassburg merchant the cost of warehousing, this route is taken by part of the wheat.

Of the special export trade of 2,183,000,000 francs, iron and steel form 8½ per cent., machinery and coal amount each to about 5 per cent., raw wool, linen yarn, diamonds (cut at Antwerp) and flax each to over 4 per cent., wheat, zinc, and indiarubber (from the Congo) over or nearly 3 per cent. Germany takes 23 per cent., Britain 18 per cent., France 15½ per cent., and the Netherlands 12 per cent. of these exports, the United States only 4 per cent.

Belgian imports for home use are valued at 2,782,000,000 francs. Wheat figures prominently and amounts to nearly 11 per cent. of the total. Timber, raw wool and flax each come to about 5½ per cent. Hides, diamonds, coffee, chemicals, coal, iron ore, raw cotton, machinery, are among the other important items.

Most imports come from France, nearly 17 per cent.; Germany and Britain, each about 12½ per cent., Netherlands, 9 per cent., United States, 8 per cent., Russia, 8 per cent., Argentina, 7 per cent., and British India, 5 per cent., are the other chief sources of supply.

Switzerland, the German Customs Union, and the Netherlands. The Central European countries have not the advantage of France in position, although in the sheltered valleys of the south the vine comes to perfection. Although Alpine tunnels and the Rhone valley afford routes to the Mediterranean, still most of the commerce finds its way north to the Rhine, Weser, Elbe, and Oder ports.

The Swiss and South German farmers cultivate maize, wheat, flax, hops, chicory, and tobacco on the richer lower plains, and barley, oats, and rye on poorer soils and higher fields. The terraced lower sunny slopes of the hills are covered with vines and the rest with forest, up to the level of Alpine meadows above which comes the snow line in Switzerland.

The North German and Dutch plains are not suited for maize, and even wheat is not much cultivated. Towards the east and south-east rye becomes the most important crop. Potatoes, from which spirit is distilled, are abundant in the middle Elbe and all of the Oder basins, and sugar beet is a most valuable crop in Silesia and the area between the middle Elbe and Weser.

The Swiss Industrial Area. An important industrial area lies in the northern plateau of Switzerland, between the Alps and the Jura. Though hampered by an absence of coal, Swiss energy and education have developed great industrial prosperity, which is expanding with the increased utilisation of the abundant water power converted into electricity. Engineering works are important in the great towns of the north, especially at Zürich and Winterthur (locomotives). Cottons are made at St. Gallen and Zürich, and silks at Zürich and Basel. The watch trade is commonest in the south-west round Chaux-des-Fonds, Le Locle, and Geneva.

Swiss Trade. Switzerland exported 935,000,000 francs worth of goods in 1904, and over 1,000,000,000 francs in 1905. Its manufactures, silks (25 per cent.), cottons (18 per cent.), clocks and watches (13 per cent.), and its preserved foods, cheese, condensed milk, chocolates, spirits (13 per cent.), are sent, not merely to adjacent countries, but over the seas. While Germany takes 22½ per cent., Britain takes over 19½ per cent., America 15½ per cent., and France only 11½ per cent. of the exports.

Swiss imports in 1904 amounted to 1,323,000,000 francs and in 1905 to 1,433,000,000. Switzerland has to import food for its industrial population (23 per cent.), while raw and manufactured silk, cotton and wool, metals and minerals form the next important items.

Germany (28 per cent.), France (18 per cent.), Italy (13 per cent.), America, Austria-Hungary, and Russia (each between 6 per cent. and 7 per cent.) supply the bulk of these commodities, the British proportion being under 4½ per cent.

The South German Industrial Areas. The industrial areas in South Germany are in small groups. The only coalfield is that of the Saar valley, where ironworks are important, as well as in the Grand Duchy of Luxemburg. The iron ores east of Nürnberg supply material for the other smelting works. Engineering is important in the capitals of the different states and in other large towns. Cotton manufacturing is the most important textile industry, and is carried on at Mülhausen and Colmar in Alsace, Freiburg in Baden, where some silk is also made, and at Stuttgart, Darmstadt, and other towns in Central and Southern Württemberg. Greater use is being made of the abundant water power of the southern highlands. Chemical works of great importance exist in the northern part of this area in Ludwigshafen, Mannheim, Frankfurt-am-Main, Nürnberg, and Stuttgart. Brewing is important all over Germany, especially round Munich and the other capitals.

Silesia and Saxony. The Silesian industrial area is near rich fields of bituminous and of brown coal. Iron industries are common near the former, at Gleiwitz, Königshütte. Engineering works exist in the larger towns such as Breslau and Liegnitz. The local flax and wool make linen and woollen manufactures important all along the base of the Sudetes, especially at Schweidenitz, Liegnitz, and Görlitz. Cotton is spun and woven at Breslau, Glatz, and Görlitz. Sugar is extracted from sugar-beet, at Breslau and other centres.

The Saxon industrial area has important coal, iron, and other metalliferous deposits. Freiburg is the chief mining centre. Chemnitz, Dresden,

Leipzig, and all the larger towns have engineering works. Local wool makes the fabrication of woollen goods very important. As Saxony is in closer touch than Silesia with the oceanic routes by the Elbe and Hamburg, cotton manufacturing is much more important in Saxony, and is carried on at Chemnitz, Zwickau, Plauen, and other centres. The potteries of Meissen (Dresden ware) and the book trade of Leipzig are special industries of this region. The salt of Halle, Stassfurt and other centres gives rise to chemical works.

North German Industries. The industries of the North German plain consist mainly of those which elaborate agricultural produce. The most important is the preparation of sugar from sugar-beet, especially between the Elbe and Weser. Halle, Magdeburg, Brunswick, Hanover, and Hamburg are among the more important centres. Potato spirit is also made in these towns. Cement manufacturing is carried on round Hanover. Berlin has the furniture, clothing and other manufactures of a great capital, and it possesses the great advantage of being reached both by water and by rail. Hamburg may be regarded as the North Sea port of Berlin and Stettin its Baltic seaport.

Westphalia and the Rhineland. The Westphalian and Rhineland industrial area is the most important of all. Rich in coal and iron, it has the great Krupp works at Essen, the hardware of Remscheid, and ironworks at all the chief centres, Aachen, Cöln, Düsseldorf, Dortmund. Woollens from local and imported wool are made at Aachen, Barmen-Elberfeld, and other centres. Barmen-Elberfeld and Crefeld are famous for silks and cottons, the latter made at many other centres in this busy area.

The Rhine here is the natural highway. The ports, such as Düsseldorf, Duisburg, and Cöln, rival in the amount of their tonnage that of great ocean ports. Yet the Rhine is under the great disadvantage of reaching the sea beyond German territory, so the Germans are constructing great canals to join this industrial region to the North Sea at Emden and Bremen. The canal from Dortmund to the Ems is now complete, and is being extended to the Rhine. It was proposed to construct a great canal from the Rhine to the Vistula, but the opposition of the Prussian landlords, who realise that cheaper canal communication would facilitate the competition of foreign wheat in inland centres with home wheat, and also that of the merchants of Hamburg, who feared the gain would be that of Bremen, at the expense of Hamburg, led to an abandonment of the full scheme and the authorisation to construct the canal only as far east as Hanover.

German Exports and Imports. The German Customs Union, or Zollverein, includes Luxemburg. In 1904 the special exports were valued at 5,315,000,000 marks (1 mark equals 1 shilling), and in 1905 at 5,693,000,000 marks. Textiles were by far the most important (in 1904, 23½ per cent.), metals and metal ware coming next (over 16 per cent.), articles of consumption and chemicals (each over 9 per cent.), machinery and leather goods (each over 7 per cent.) coming next.

Britain is Germany's best customer as it is of France, and takes 19 per cent. of the exports. Austria-Hungary takes 11 per cent., North and Central America 10½ per cent., the Netherlands 8 per cent., Russia and Switzerland both over 6 per cent., France 5 per cent., South America and West Indies also 5 per cent.

The German imports were valued at 6,864,000,000 marks in 1904, and 7,046,000,000 in 1905. Unlike France, Germany cannot feed its people on its own produce. Hence, nearly 25 per cent. of the imports consist of articles of consumption. The textiles and raw material for textiles imported are not far short of this large percentage—*viz.*, 22 per cent., and metals and metal ware nearly 14 per cent. The food sent from North America makes it the chief source of German imports, over 14½ per cent., but Britain is only a fraction less important—*viz.*, just under 14½ per cent.; Russia comes third, over 12 per cent., Austria-Hungary 10½ per cent., and France over 6 per cent. British trade with Germany, as with France, is first in importance.

The Netherlands. Holland has little mineral wealth. It can import coal cheaply across the North Sea. It is essentially, however, an agricultural and commercial country, the industrial developments being mainly in the elaboration of produce from the rich Dutch colonies, especially those in the East Indies. Sugar and cacao are among the most important, but some woollens and cottons are manufactured. [See also page 1836.]

Dutch trade of home produce or for home use was valued in 1904 at 1,986,000,000 guilders exports, and 2,420,000,000 guilders imports (12 guilders equal £1). The following table shows the relative proportions of different classes of commodities in 1903 and 1904:

—	Imports, 1,000 gl.		Exports, 1,000 gl.	
	1903	1904	1903	1904
Food products ..	625,698	607,287	603,102	544,562
Raw materials ..	557,010	577,029	425,309	452,222
Manufactured products ..	277,440	263,966	269,345	252,355
Miscellaneous ..	427,608	515,491	327,186	375,428

Dutch exports consist of cereals and flour, copper, iron and steel, textiles, butter and margarine, cheese, vegetables, flax. Fifty-two per cent. goes to Germany, 22 per cent. to Britain, 11 per cent. to Belgium, 5 per cent. to the United States, and 3½ per cent. to Dutch colonies.

Cereals and flour are the chief imports, followed by iron and steel, textiles, copper, coal, rice, wood, and coffee. Nearly 23 per cent. comes from Germany, 15½ per cent. from the Dutch East Indies, nearly 14 per cent. from Russia, over 10 per cent. from Belgium and from Britain, and just under 10 per cent. from the United States, while 3 per cent. comes from British India.

It is not possible to analyse our trade with Holland from our own trade returns, as much of it is trade with Germany passing across the Netherlands, which has a very large transit trade by rail and by the Rhine.

Continued

PAPERING, PAINTING, & GLAZING

The Tools and Materials Used by Painters, Paperhangers, and Glaziers. The Methods of Executing Various Kinds of Work

Continued from page 5799

By Professor R. ELSEY SMITH

PAPERHANGING

THE work of the paperhanger consists in preparing the surfaces of walls and ceilings, trimming and preparing paper of various kinds and other hangings with which in these days walls are frequently ornamented and in some cases protected.

Paperhangers' Tools. The tools used by the paperhanger are not very numerous. One may include with them overalls, which are generally made of "duck" or "drilling," which are always worn by the paperhanger and which are formed with pockets for rule and shears and a wide pocket across the front. *Shears* [18] are required for trimming papers before hanging; long ones are from 14 in. to 16 in. long, but shorter ones are also required. A *trimming knife* [19] is required of thoroughly well tempered steel; this has a deep blade with a rounded cutting edge, and is made in one or two different forms. It is used against a straightedge when trimming. A *cutting wheel* [20] is often used. This is really a circular knife with a thin, fine edge, which may readily be kept in a sharp condition. A variation of this knife, known as the *twentieth century cutter* [21], is provided with a ratchet. When the wheel is drawn forward it becomes locked, and a definite portion of the circumference acts as the cutting edge; by pressing the wheel backward it rotates slightly, another cog of the ratchet becomes locked and a fresh part of the circumference comes into play, so that a keen edge may be in use until the whole circumference has been brought into play, when it must be re-sharpened. These cutters may be used for trimming paper either dry or pasted.

There are various machines for trimming paper in long lengths before it is pasted, and these are made to trim one or both edges at once for any paper up to 22 in. wide. The *Empire trimmer*, made by Mr. J. Oates, of Huddersfield, has a rod in front of the machine on which the roll to be cut is placed, and a second roll at the back on which it is wound after cutting. The position of the cutting wheels can be adjusted to the exact width required.

Trimming Wallpapers. Great care is required in handling rolls of paper that have been trimmed mechanically; this is usually done at the shop, and if the rolls are afterwards taken to the job and made to stand on their ends, the carefully-trimmed edges will be damaged. Ordinarily, trimming is done on the job just before hanging, and all such damaged edges are removed by trimming; this operation is carried out on a trimming table erected on a pair of light trestles.

The *smoothing brush* [22] is a broad brush from 10 in. to 14 in. wide with a wooden back grooved to allow of its being held readily; these brushes are generally made of white Russian bristles.

Seam rollers are used for smoothing joints and are made of rosewood or ivory or of rubber [24], or they may be finished with a layer of felt, covered with muslin, which may be readily renewed when soiled. The width of the roller is from $1\frac{1}{4}$ in. to 2 in., and the surface is either cylindrical or barrel-shaped. In order to get close up to the work round the edges of architraves to doors and windows, and in similar positions, a *side arm roller* [25] is employed.

Smoothing rollers [23] are usually about 8 in. wide and are used for running over the general surface of work. They are sometimes made of polished hardwood mounted in nickel-plated frames; but in many cases these are also finished with a layer of felt, which is covered with muslin held in position by rings at each end.

The *brushes* [26] used by the paperhanger are made of long grey bristles mounted in wood handles so that they form a flat kind of brush from 6 in. to 8 in. wide.

A *size kettle* [27] is best provided with a water-jacket to prevent any possibility of the size being burnt when heated.

The paperhanger requires to use a plummet, a chalk line, a 2-ft. rule, a pail for paste, sandpaper, a tape measure, and compasses, and, very usually, cloths for smoothing down the paper in place of the smoothing brush already described.

Wallpapers. *Wallpapers* are made by various processes and are sold by the piece. In the case of English paper the piece is 12 yd. long nominal, and the paper is about 22 in. wide as sold, and 21 in. when trimmed for hanging, and has a superficial area of 63 sq. ft. French papers vary somewhat in length, but are usually 9 yd. long and 18 in. wide, and contain $40\frac{1}{2}$ sq. ft. American papers are 8 yd. long and 18 in. wide, and contain 36 sq. ft. The pattern of a paper must therefore be made to repeat once or oftener exactly in the width of the roll. Borders and friezes are usually sold by the yard.

Papers that are printed are either machine printed or hand printed. The best results are obtained by hand printing, which is done from wood blocks; these papers may be known by the presence of a white margin at each end of the roll, as well as at each edge; this results from printing each piece separately, whereas machine-printed papers are printed in immensely long rolls and afterwards cut up into lengths, so that the pattern runs out to the very end. The colours in machine-printed papers are not always so well set as in the case of those printed by hand.

Pulp papers are the commonest class of papers; in these the paper itself may be a tinted paper and the pattern printed in colour, or in better papers both the ground and the pattern are printed.

Satin papers have a glazed or polished surface, giving an effect like satin; this is produced by mixing Spanish white with the colour and then thoroughly burnishing the surface. This class of paper is somewhat susceptible to damp, and it is often desirable to line the walls with lining paper before hanging it; but these papers usually keep a clean surface, as dirt does not readily adhere to them.

Flock papers have the patterns printed on a ground with an adhesive substance, and upon this shearings of wool or silk, very finely divided, are sprinkled, and these adhere, forming a raised pattern; the

wool flock gives a somewhat cloth-like or velvety appearance; the silk a somewhat glistening effect, and striped silk flocks are a good deal used.

Sanitary papers are printed from copper rollers in oil colour mixed with a strong adhesive material; such papers, when hung, may be washed, which is not possible with ordinary papers.

Ingrain papers, which are not printed, but coloured in the manufacture, are prepared in various tints, with a slightly mottled surface, and are rather soft and porous; papers are also made to imitate tapestry and other textile fabrics.

Special Wall Coverings. There are many other forms of wall hanging now in use, which are of a more substantial and permanent character than the ordinary wallpaper. They are, as a rule, considerably more expensive in the first instance, and require special treatment in hanging. Some of them are supplied decorated ready for hanging, others can be obtained perfectly plain for decorative treatment after fixing.

Japanese leather papers are thick in substance, usually slightly embossed, and decorated in colours with which a good deal of metal bronzing or gilding is included; these papers are usually supplied in rolls 36 in. wide and 12 yd. long, and in the majority the design is rather large in character.

Lincrusta Walton is a material generally modelled solidly in relief, and is produced in a great variety of designs suitable for dados, wall surfaces, friezes and also for ceilings. It forms an excellent base for colour decoration, and some of the designs in high relief may be treated plainly in one colour, a good effect being obtained by the contrast of light and shade without any picking out. *Cordelova* and *cameoid* are other forms of material manufactured and supplied by the same firm, and are also made in both low and high relief; in the latter form, when used for ceilings, they may be arranged to give the effect of plaster panelled ceilings.

Lignomur is another material with the design formed in relief. It is manufactured of wood fibre, and is embossed in hollow relief; it may be applied to walls or ceilings, and afterwards decorated in a variety of ways, either in oil colour or distemper, or it may be stained and varnished, as if it were a natural wood.

Anaglypta is also moulded in relief, both high and low, and is made by pressing pulp or plastic paper into moulds.

Tynecastle canvas is very extensively employed, and is also modelled in hollow relief, canvas being employed as the basis of this material; very bold relief is possible, and the material lends itself to decoration in colour after hanging.

Woven Wall Coverings. Woven and embroidered fabrics, used as hangings or mounted on frames, have long been used for covering walls, and come rather under the upholsterer's department than the paperhanger's. The drawbacks to such materials—their liability to become soiled, the difficulty in changing them, and the extent to which they may harbour dirt, and even vermin—have been serious drawbacks to their admirable qualities from the decorative and artistic points of view. In recent times, some of these materials, the texture of which is admirable, have been prepared so that they may be applied to the wall by the paperhanger practically in the same way as a wallpaper. To render this possible, the space between the fibres must be filled, and especially the back, so that it may adhere solidly to the wall, and not allow the paste to work through to the surface; the material itself must be dyed and fixed so that it will not readily fade.

Burlap, made from jute, is extensively used for this class of work; the fibre is lustrous, and the material strong and not very expensive, and admits of the surface being treated in colours, which may be either printed or stencilled on it. The material can also be obtained in very wide widths, so that it is possible in many cases to get a material the width of which will equal the height of the wall space, and which may be run round the walls without many joints; where there are not many openings or recesses to be dealt with, they may be readily cut out of the material. This material may be used in narrower widths as a dado or frieze in combination with papered walls, or as a filling to panels

Prepared canvas may be applied in a similar way to walls and ceilings, and afterwards decorated in either oil or water colour, and either of these materials not only forms a suitable decorative surface, but prevents the appearance of surface cracks, such as frequently arise with ordinary plastered ceilings.

Calculating Paper Required. The paperhanger is required to estimate the amount of paper required for any particular piece of work. The experienced man can tell pretty closely without measurement the number of pieces required for any particular room, but it is easy to ascertain the superficial area of the walls of any room, and, bearing in mind the amount of paper in a roll, already given, to see exactly how many pieces will cover it. But allowance must also be made for waste; this occurs not only in fitting paper round door and window openings, fireplaces, and recesses, which often accounts for a good deal, but there is also often considerable waste in cutting up paper so as to ensure that the pattern shall match exactly when two pieces are hung side by side. If the pattern is small, so that in height it exactly repeats every few inches, this loss will not be great, but if the pattern is large, and only repeats once or twice in the height of the wall, it may easily happen that a considerable amount may have to be wasted for every length cut from the roll. It is usual to allow one extra roll for each five to eight rolls required exactly to cover the wall, the specific allowance depending on the probable waste.

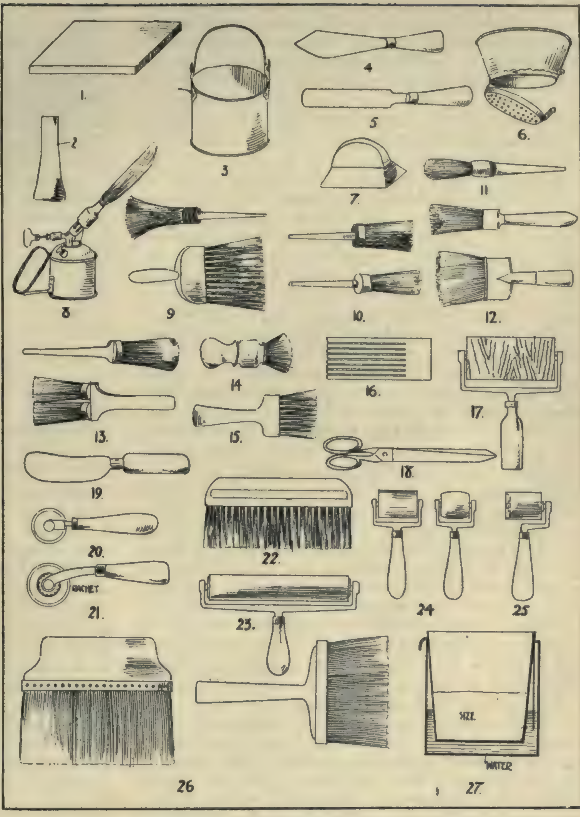
Trimming Paper. Wallpapers are delivered in rolls with a margin on each side, which must be trimmed off before the paper is hung. The machines used for trimming have been described, but the old-fashioned method of trimming, by means of a large pair of scissors or shears, still prevails. The roll of paper is laid on the trimming-board and unrolled, trimmed with the shears on one edge, and re-rolled during the operation, which is repeated for the other edge.

Preparing the Walls. In the case of new walls, the surface should be sized with glue size [see Painting, page 5502]. It is well to point out that in the case of most plastered surfaces the lime in the plaster is very liable to act on the colours used for printing designs on wallpapers, and also on ingrains, and destroys them. This action is worse if there is any damp, but may occur even with dry plaster, and may continue for several months at least after the wall is plastered. It is particularly likely to affect green and some other delicate tints, and it is desirable, as a rule, not to hang an expensive wallpaper on new walls within twelve months of the plastering, but to cover them temporarily with a tinted lining paper, or to distemper them.

In the case of old walls, it is important that the old paper should be stripped; if this is not done, the dirt, and possibly disease germs, in the old paper will only be covered over. Paper may be removed by washing it over with hot water, and then scraping it off, taking care not to damage the plaster. Paper that has been varnished after hanging is often very difficult to remove. A coat of hot paste applied to the surface will, as a rule, soften it, but a special varnish remover may be required, and in some cases where the paper was porous the varnish penetrates to the plaster, and it is almost impossible to remove it without destroying the plaster surface.

A varnished surface does not hold either dirt or germs to the extent that an unvarnished paper will, and the surface, if it is left, may be cleaned, and the joints rubbed smooth with pumice; the surface may be prepared by giving it a coat of brown sugar mixed with water in the proportion of 2 lb. of sugar to 1 pail of water.

Repairing Walls. In the case of old walls, all nails must be extracted and any defects in the plaster made good. This is properly the work of the plasterer, but the paperhanger may often have to execute small repairs. Such repairs are usually executed in plaster of Paris, or in plaster mixed with fine lime putty [see Plastering], and care must be taken to see that the surface of the repair is truly in the same plane as the general wall surface.



PAINTERS' AND PAPERHANGERS' TOOLS

1. Grinding stone 2. Muller 3. Paint-pot 4. Stopping knife 5. Palette knife 6. Strainer 7. Felt rubber 8. Painters' torch 9. Dusting brushes 10. Ground brushes 11. Sash tool 12. Varnish brushes 13. Distemper brushes 14. Stencil brush 15. Badger softener 16. Grainer's comb 17. Graining roller 18. Shears 19. Trimming knife 20. Cutting wheel 21. "Twentieth Century" cutter 22. Smoothing brush 23. Smoothing roller 24. Seam rollers 25. Side-arm roller 26. Paste brushes 27. Size kettle

When plaster has been damaged by blows, which is liable to occur—as, for example, by the handle of a door opened back against it — ordinary repairing in plaster is useless. In such a case the plaster may be neatly cut out in the form of a square, and a piece of wood let in, screwed if possible to wood plugs let into a brick wall, or to the quarters of a partition, but in some cases merely to the laths. In this case, also, care must be taken to see that the surface is uniform with the wall, and if sunk a little below it, the extra thickness may be made up by pasting one or more neatly cut sheets of paper over it.

Paperhangers' Paste. Pastes are employed by the paperhanger varying in strength with the class of material to be used. The following recipes are given in Rivington's work, and the best white wheat flour should be used as the basis of them all.

No. 1. Beat up 4 lb. of flour in cold water to a stiff batter, getting rid of all lumps; add enough water to bring it to the consistency of pudding batter. Pour boiling water over it, stirring rapidly; when the mixture swells and loses the white colour of flour it is ready for use.

No. 2 is made like No. 1, but, just before the boiling water is added, 2 oz. of alum are mixed with the batter; this hardens it and is a good preservative. This form of paste may be used for flock papers, but alum must not be used with gilt papers, as it turns the metal dark.

No. 3. Make a batter as in No. 1, but of less consistency, and to 2 qts. of batter add ½ oz. of powdered resin. Set the mixture over a moderate fire, stirring it till it boils and thickens; allow it to cool, and thin it with thin gum arabic water. This is used when strong adhesion is required, and is useful in papering over varnished or painted surfaces.

No. 4 is the same as No. 3, but without the gum arabic, and is used for securing the edges of flock papers.

Some special pastes for hanging heavy goods will be described later.

Hanging Wallpapers. Quite apart from the mere mechanical part of hanging there is need for a good deal of judgment in the setting out of the paper so that it will look well on the wall; it often happens that by shifting the paper up or down a few inches the effect may be considerably improved, or the reverse. It is very important also that any well-marked pattern should be properly centred in the most prominent feature in any room; this is very usually the chimney front. This careful

centring is, if possible, of even more importance in papering ceilings, for the whole expanse is seen at once, and if the pattern is not set out centrally in the room a very bad effect is produced.

Special care must be taken to see that the first strip hung on a wall has the edges truly vertical, and a line and plummet may be used to set out a vertical line, which may be marked on the wall surface with chalk.

Pasting the Paper. A length is cut off from the roll a little longer than the height between skirting and cornice, laid face downwards on the table, and the back pasted over uniformly and not too thickly, working from the centre outwards. After pasting, the ends are folded back towards the centre, the edges being kept even; if the strip is too long for the table, one end is first pasted and then folded over, then the paper is drawn along and the other end pasted and folded. The actual hanging requires skill and experience. The upper edge is usually cut exactly, and is fitted against the cornice mould or picture rail, and the upper half of the paper unfolded, placed in contact with the wall, and brushed down with a cloth, brush, or roller; care must be taken not to work the paste towards the outer edge or it may be forced out in lumps. When one piece is hung it serves as a guide to the others, which are added right and left. In hanging the last piece there may be some difficulty in matching exactly the patterns at the joint, especially if the design is large, and any such irregular join should be contrived where it will be as little obtrusive as possible. Where an angle occurs it is often found not to be quite straight, and it is best to cut the paper so that a join will come close to the angle and not to use a whole width. When each strip is hung the bottom edge usually overhangs the skirting slightly, and when it has been rolled or brushed down close to the bottom the lower end is lifted slightly, the point of the shears drawn along to mark the exact length, and it is then trimmed and afterwards pressed down. The narrow rollers are used for the joints. The joints are usually formed by butting one piece of paper close to the next piece, and where this is done both edges must be trimmed; in common work one selvedge is left on and the edge of the next piece pasted over it, but this causes a ridge at the joint. In arranging ceilings the paper should be set so that the joints run in the direction of the window, or if there are windows on adjoining walls then towards the strongest light. Where a good class of paper is hung on new walls they are often first hung with lining paper and then with the wall-paper itself.

Hanging Special Wall Coverings. Where heavy, embossed papers are employed it is usual to prepare the wall by hanging strong brown paper as a lining. In the case of most kinds of special hangings full instructions are issued by the makers and these should always be observed.

Lincrusta Walton, if the weather is cold, should be placed in a warm room before it is unrolled. The edges must be trimmed very carefully, using a metal-edged straightedge and a sharp leather-cutter's knife, which is stiffer than a paperhanger's. The paste is used hot and the lengths, after pasting, are applied to the wall, and well rubbed with a stiff, short hairbrush, or a soft, spherical rubber roller. If blisters appear they must be pricked and then rubbed down. The paste may be ordinary paste mixed with half the amount of glue, but the following composition is recommended by the makers: French plaster of Paris, 4 lb.; raw linseed oil, 1 pint; these are rubbed together through a sieve; 1 lb. of white glue is well boiled in $1\frac{1}{2}$ gallons of water and poured in hot, and the whole left to get cool, being stirred to thoroughly mix it.

Anaglypta is trimmed with a metal straightedge and pasted with ordinary paste; after about fifteen minutes it is again pasted with stiff paste containing from $\frac{1}{4}$ to $\frac{1}{2}$ glue, hung at once, and pushed home with a cloth.

In hanging *Lignomur* no glue must be used, but the paste should be as stiff as it can be made. Tynecastle canvas is treated in the same way as Lignomur, but it is not necessary to mix glue with the second coat of paste.

Japanese leather papers are hung with ordinary paste, applied to the paper as a first coat, and after two or three minutes a second coat is applied, mixed with a proportion of glue.

PAINTERS' WORK

The work of the painter consists in covering perishable or common materials with a thin material that will protect them from decay, enable them better to resist ordinary wear and tear, or give to them an improved appearance.

Painters' Tools. The painter's tools are comparatively few in number. A *grinding stone* [1] is required for grinding colours; this is usually a slab of marble about 2 ft. square; the *muller* [2] is about 7 in. long and 4 in. in diameter, and is of granite or other very hard material. Where paint is required in large quantities it is, however, ground in a mill. There are also *pots* of earthenware or tin for holding colours of various sizes, a *pallet* to hold small quantities of colour for use in letter writing and small decorative work, and a *mahlstick*, used as a rest for the hand in letter writing and small decorative work.

The *stopping knife* [4] is one with a stiff blade set in a wooden handle. From the handle the blade broadens outwards, the back is straight till the broadest point is reached, and the end is rather sharply pointed; the lower edge is without a sharp angle, but is slightly rounded so as to form the point. This tool is used for *stopping* surfaces that are to be painted—that is, filling in any small holes with putty or other special stopping.

The *palette knife* [5] is one with a long, broad, flexible blade, parallel sided, and with a rounded end fixed in a wood handle. It is made in several sizes and is used for mixing paints.

The *painter's can* [3] is a circular metal case with a flat bottom and a movable handle of iron, by which it is carried; it is used for mixing paints and for containing them during use.

A *strainer* is used for straining paint after it has been mixed, and, before use, to rid it of all irregularities and lumps. Strainers are of various forms; the simplest resembles an ordinary colander but with a flat bottom, which is perforated with very fine holes, through which the paint is passed, a stick or brush being employed to work it about and assist it through. Another form [6] has a hinged bottom perforated with large holes, and over these a piece of muslin or cheesecloth is strained, and this material, if it becomes clogged with particles of paint, can be renewed at any time.

The *felt rubber* [7] is a flat tool formed at the back into a handle and covered with felt, and is specially used for rubbing down varnished work.

The *painter's torch* [8] is a small lamp, producing a strong flame with a forced draught, which is used for burning off paint, and can be held in the hand and moved over the surface of the paint to be

removed; where gas is available a burner on the principle of a Bunsen burner, producing a flat flame, may be used for the purpose.

Brushes are the most important tools the painter uses, and with these the material is actually applied to the surface to be covered; they are made in various sizes and forms, depending on the nature of the material to be employed and the method of using it. Good brushes, if properly cared for, will last a long while, and it is desirable they should be of good quality and made by a firm of standing.

Dusting brushes [**9**], both round and flat, are required to prepare work for painting; like other brushes these are provided with wooden handles, are of different sizes, and are kept dry for dusting only.

Brushes for applying paint differ much in size and form, each class of brush being made in a series of sizes, which are regularly numbered.

Ground brushes [**10**] are fairly large brushes employed for large, plain surfaces and are made round or oval in form; they are formed of hogs' bristles and are well bound round at the base with twine to keep the bristles compact, or have patent metal ferrules.

The *sash tool* [**11**] is a smaller class of brush, used for painting mouldings, sash bars, and similar work. These are also made in different forms, but an oval-shaped brush is very generally used.

Varnish brushes [**12**] are either round brushes brought to a broad thin edge or are broad brushes mounted in a metal frame.

Distemper brushes [**13**] are large brushes used for whitewashing and distempering; they are termed *one-knot* or *two-knot*, according to the manner in which they are made up; and flat brassbound brushes are also employed for this work.

Stencil brushes [**14**] are used for stencilling designs in distemper, and are short metal-bound brushes.

A *badger softener* [**15**] is a brush used in graining work to give a woody appearance to the work.

Care of Brushes. It is important that brushes, if they are to be kept in good working order, should not become caked with paint. It is not necessary to clean brushes after a day's use if they are to be used again within a day or two, but they should be suspended in raw linseed oil or in water to keep them moist, and so that the points do not touch the bottom of the vessel; for if the bristles rest on the bottom they are apt to be bent.

The oil or water can readily be squeezed out of the brush by drawing it firmly across the edge of a piece of board when the brush is required for use. If brushes are to be out of use for some time, they must be thoroughly cleaned in turpentine or with soap and hot water, dried, and afterwards wrapped in clean paper and put away in a dry, cool cupboard.

Grainers' combs [**16**] are required for work to be grained, and these are made in various degrees of fineness.

Graining rollers [**17**] are employed for some kinds of graining. The colour is supplied by a brush to a series of discs on the roller, which are notched at intervals, and produce dark broken lines in the work, or the roller may have the pattern of the grain incised on its surface.

Pumice-stone is used for rubbing down work before applying fresh coats of paint, and fine glasspaper is used in a similar manner.

Paint-spraying machines consist of a pumping apparatus attached to a hose fitted with a perforated nozzle; they are chiefly used for distemper, lime white, etc., and the material is sprayed on to the surface very rapidly and evenly, and reaches all crevices or irregularities.

Painters' Materials. The materials used by the painter are either opaque, so that they entirely cover and conceal the real surface of the material, or they are transparent or semi-transparent, allowing the natural surface to be visible.

Of opaque materials, those in most general use are termed *paints*, and when mixed ready for use are usually made up of *vehicles* (which are liquid substances holding other matters in suspension, and permitting of their even distribution over the surface), *driers*, which are oxidising substances enabling the vehicles to dry rapidly, and *pigments*, or colouring materials. Pigments are finely powdered, and held in suspension by the vehicles.

Vehicles are of different kinds. For water-paints, ordinary water is used, and this class of vehicle is employed not only for water-colour drawings, but for whitewash and distemper. For most painted work, however, the vehicle is either a fatty or fixed oil—that is, one that cannot be distilled, or a volatile oil that may be distilled; and not uncommonly both these classes of oil are employed in mixing paint for use.

Oils. *Linseed oil* is the most usual of the fixed oils, and is obtained by crushing the seeds of the flax plant. In common with other fixed oils, it does not dry by evaporation but by the absorption of oxygen, and during the process attains great toughness and flexibility. When applied to wood surfaces, it sinks into the pores of the wood, and hardens, forming a protection from the weather.

Raw linseed oil is the oil in its natural state. In this condition it is of a bright amber colour, and dries somewhat slowly. If spread in a film on a non-absorbent material it takes from two to three days to dry; the bright colour makes it unsuitable for mixing with delicate shades, and if it is to be used for such work it may be clarified with oil of vitriol, which must, however, be afterwards washed out. The material improves in quality and colour by keeping for some years, and should not be used until it has been kept for six months at least; it is generally employed for most internal work in which linseed oil is the vehicle and for grinding up colours.

Boiled linseed oil absorbs oxygen more rapidly than the raw oil. The process of boiling consists in heating the oil (which does not actually boil) to about 200° F., and then adding to each gallon of oil about 1 lb. of red lead and 1 lb. of litharge, and raising it to a temperature of 400° F., which is maintained for two or three hours. If a dark-coloured oil is required, umber may be added also during the boiling process. The oil, after boiling, is drawn off and allowed to settle, and is then bright and clear, but darker than the raw oil.

If the oil is to be mixed with zinc-white as a pigment and not white lead, the oxides of lead should not be used in the boiling process, but about 5 per cent. by weight of powdered peroxide of manganese is substituted, and the oil is afterwards filtered. The drying and the colour of raw oil may be improved "by adding about 1 lb. of white lead to every gallon of oil, and allowing it to settle for at least a week" ("Builders' Work"—Seddon).

The boiled oil dries more quickly than the raw oil; if spread on a non-absorbent material it should be quite dry in from twelve to twenty-four hours. It is particularly well suited to external work, when rapid drying is of great importance, and in which tints of a delicate nature are rarely called for.

Poppy oil is extracted from the seeds of the common poppy; it is inferior to linseed oil in both tenacity and in its drying qualities, but is very

nearly colourless, and is therefore sometimes employed for mixing with delicate tints in internal work.

Nut oils are usually extracted from walnuts, and are cheap, but not durable, and are suited only for internal work of a temporary character.

Turpentine. *Oil of turpentine*, also known as *spirits of turpentine*, abbreviated commonly into *turps*, is a volatile oil obtained by distilling turpentine—a resinous exudation from certain trees which contain resin and oil of turpentine. This oil has a strong odour, and when exposed to the air absorbs oxygen, and is converted into a substance resembling resin. It is used as a solvent for gum resins, and also for mixing paints in combination with linseed oil, or by itself when a flatting coat is required—that is, one without a glossy surface. When spread on a non-porous surface it should dry in twenty-four hours, leaving a hard varnish on the surface.

Strasbourg turpentine is produced from the silver fir, *Venice turpentine* from the larch, and *common turpentine* from the Carolina pine.

Driers. *Driers* are mixed with paints to assist the drying of the vehicles when this is necessary. The drying of linseed oil is produced by the absorption of oxygen as already mentioned, and the driers which are usually employed are materials rich in oxygen, and readily yielding up the oxygen to the oil, thus hastening the process. The action of some of the pigments to be hereafter described is to retard the drying process, and driers are specially valuable when such pigments must be used in mixing paints, otherwise the paint would continue for a long time in a semi-dry condition, known as *tacky*. During this time it is slightly sticky, or adhesive, if touched.

The most usual driers for use with light tints are *acetate* or *sugar of lead* and *sulphate of zinc; litharge*, or oxide of lead, which is produced during the extraction of lead from its ores, is very commonly used for all darker tints. For use with lakes, *japanners' gold size* is used, which consists of oil boiled in litharge. For use with zinc-white, *sulphate of manganese* is an efficient drier, a very small quantity sufficing; but care must be taken in mixing it or the paint may be spotted. Another drier used with zinc-white is that made by adding about 10 per cent. by weight of a mixture formed of boiled linseed oil (20 parts) and peroxide of manganese (1 part). It is important to select a drier suited to the pigment to be used, and to observe the following points, which are taken from Seddon's "Builders' Work."

1. Do not use them with pigments that dry well in oil colour.
2. Do not employ them to excess, which would retard the drying.
3. Do not add them to the colour till just before it is used.
4. Do not use more than one drier with the same colour.
5. Avoid the use of patent driers.

The result of using driers in excess may be the drying of the surface with abnormal rapidity, so that a thin skin is formed which, at a later time, may become softened by the action of the undried paint behind it, and remain tacky for a long time. Patent driers are in the form of paste, and are slightly more economical than the ordinary liquid driers, but vary much in quality and in their effect on the paint.

Pigments. *Pigments* are the solid matters introduced into paints to give *body*—that is, solidity—substance, and opacity to the paint, and also to give to it any desired tint or colour. They are in most cases earthy or metallic carbonates and oxides, and are very finely ground; they are sold in a dry form as powder, and also ground up in oil. They may be divided into two main classes—namely, *bases*, which are used to produce body and opacity, and *colouring pigments*, which are used to produce various tints and colours, especially in the finishing coats.

Bases. *White lead* is prepared by various processes. The Dutch process produces the best, and consists in placing gratings of pure lead in tan. The fumes of acetic acid are allowed to act on these, which become corroded and covered with a crust of *carbonate of lead*, which is commonly known as *white lead;* this is removed and ground and forms a heavy powder, which becomes grey if exposed to the air. The substance may also be prepared by passing carbonic acid through solutions of various salts of lead, but the material thus precipitated has no density, and absorbs more oil than that produced by the other process.

White lead is the most usual base for oil paint and has a very high covering capacity. It is, however, injurious to those who use it, and is very liable to be discoloured by many chemical gases, such as sulphuretted hydrogen. It should be old and not freshly made, or the paint soon loses its whiteness, but it must be protected from the air till use. It is extremely liable to adulteration, and can be relied on as pure only if obtained from the manufacturer as *genuine dry white lead*, either in lump or in powder. The materials used for adulteration are sulphate of baryta (which is similar in appearance but heavier than white lead) and whiting, which is lighter. White lead, if pure, should weigh about 400 lb. per cubic foot, and if either adulterant is used singly adulteration is detected by the variation in weight, but if the two are combined the weight may be accurately adjusted, and only a chemical test will reveal the adulteration.

White lead is often sold mixed with sulphate of baryta, which does not cover so well when mixed with oil, and when the two are mixed in equal proportions the material is termed *Venice white*, while *Hamburg white* has 1 part of lead to 2 of baryta, and *Dutch white* has 1 part of lead to 3 of baryta.

Red lead is produced by raising *massicot*, or oxide of lead, to a high temperature, during which process it absorbs oxygen and becomes converted into red lead, also known as *minium*. This material is durable if used pure and alone and not exposed to the action of acids or impure air. It is obtainable in the form of a powder and is sometimes adulterated with brickdust. Red lead is sometimes used as a drier, and it is used mixed with white lead and oil for the first coat of paint, termed *priming*, in joinery, and for the first two coats on ironwork.

Antimony vermilion, a sulphide of antimony, is sometimes used in place of red lead; it is obtained in a fine powder and is of a brilliant colour when ground in oil, and is not affected like red lead by impure air or acids.

Zinc oxide is frequently used as a base for paints; it is not poisonous like white lead, and is not liable to be discoloured by chemical fumes. When ground in oil it requires much more oil than white lead, and will require less to thin it. If it is used to give a white finish it should be mixed with refined linseed oil to secure a perfectly white surface, but this is not necessary with darker tints.

Colouring Pigments. The *colouring pigments* are much more numerous than the bases;

lists of the most usual pigments may be consulted in Seddon's "Builders' Work," under Painter, or in Rivington's "Notes," Vol. III.—Materials. These lists supply information not only as to the colour of the various pigments, but as to their nature and properties, and form a good guide as to those which may safely be used under varying conditions, and as to others which cannot be relied upon as permanent, especially if subjected to certain influences.

Mixing Paints. The proportions of the different ingredients required in mixing up paints for use necessarily vary under changing circumstances, and in particular with the nature of the material to which they are to be applied. Iron, wood, and plaster, for example, will require the paint that is to be applied to them, and in particular the first two coats, to be differently prepared, the more absorbent material requiring the use of a higher proportion of oil. The colour effect required to be produced necessarily affects the selection and the amount of colouring pigment to be added; where very delicate light tints are to be used this may affect the selection of the class of oil to be employed. The question of whether the paint is to be used for internal or external work has an important bearing on the question; in the latter case boiled oil is generally selected, on account of its superior weathering qualities. Turps is included in most paints as a thinner, its object being to reduce the consistency of the paint at the time it is applied, but it eventually evaporates and does not form a permanent ingredient.

Variation in Successive Coats. In painting any piece of work the ingredients will vary in successive coats. On any porous substance the first coat in particular must have a liberal supply of oil, which tends to sink into the pores of the material and dry there. Subsequent coats will require a certain amount of turps to make them work freely, and in painting on old work the first new coat is always mixed with a liberal amount of turps, which makes it adhere to the older work. The colouring pigments are usually mixed in with the two final coats, the last one of all being relied upon to produce the exact tint required, though the one immediately before has an important influence often on the final appearance.

Apart from any other consideration, the knowledge and skill of the individual painter always is an element in the mixing of paints; these have to be acquired by experiment and practice, which, when attained, are better than any hard and fast rules as to the proportions of ingredients.

Method of Mixing Lead Paints. If the pigment is in the form of powder it is ground up with raw linseed oil with the muller on the grindstone, and is reduced to the consistency of a thick paste, but in many cases it is purchased in this condition; if only a small quantity is required, as in the case of a colouring pigment, the paste is worked up by means of a palette knife on a slab, with the addition of a little oil and turps; but when a considerable amount is to be mixed, a painter's pot is used. The pot is first rinsed round with a little oil to prevent the white lead adhering, and then the latter is placed in it, and oil and turps added by degrees, and the lead well worked round with a stick, which may be shaped something like an oar, till the lumps are all reduced and the consistency of the whole is smooth and uniform, the palette knife being used in this operation.

If the paint is to be coloured, the colouring pigment, also ground in oil, may be added to the white lead and worked up with it if the exact proportion required is known; but it is usually better to thin it, and work it up separately, and add it to the white paint in the pot a little at a time till the exact tint or tone required is arrived at.

Adding Driers and Straining. The driers are added to the paint at this stage, and here again exact proportions cannot be given, as these vary with the nature of the drier and other circumstances; but the proportion is always small, and if a good drier is used, about 2 per cent. by weight should suffice. The rules as to the use of driers already given must be borne in mind, and in the case of a priming coat to which red lead is added, any other drier may often be omitted.

Straining the Paint. The last process in the way of preparation consists in carefully straining the paint. If this is not done, small specks and impurities are likely to be left in it, and good work will be impossible. In some cases it is useful to strain the paint two or three times. The strainer already described is made use of, the paint is poured into it, and allowed to drain out into a clean paint-pot, and it may be stirred with a stick or brush or palette knife to help its passage through the sieve, which must be carefully cleaned after the operation so as to be ready for future use.

Seddon's "Builders' Work" gives the following table of the approximate quantities of materials required for painting four-coat work to finish white and the superficial area covered by each.

PRIMING COAT. 10 lb. genuine white lead, 1 oz. red lead, 2 oz. litharge; or 1½ oz. litharge, ½ oz. burnt white vitriol, and 4 pints raw linseed oil. Will cover about 63 yd., varying with the absorbent properties of the surface.

SECOND COAT. 10 lb. genuine white lead, 2 oz. litharge, 2½ pints raw linseed oil, and 1½ pints turps. Will cover 100 super. yards.

THIRD AND FOURTH COATS. 10 lb. genuine white lead, 2 oz. litharge; or 1½ oz. litharge, ½ oz. burnt white vitriol, 2 pints raw linseed oil, and 2 pints turps. Will cover 113 super. yards.

FLATTING COAT. 10 lb. genuine white lead and 4 pints turps. Will cover 150 superficial yards. To give a very pure white, ½ oz. ultramarine may be mixed with the last coat, and for coloured paint 1 to 2 oz. of colouring pigment with each of the last two coats.

Special Forms of Paint. A large number of specially-prepared paints are now manufactured by different firms, and supplied ready for use, or requiring merely the addition of some thinning material in accordance with instructions issued by the manufacturers. It is impossible to describe or even give a full list of such paints, but many of them are designed for work in special situations, and they include various forms of enamel paints. In all cases it is necessary carefully to follow the instructions issued by the makers, and in most cases several colours can be obtained in most of the different brands.

Applying Paint. The paint is transferred from the pot and applied to the surface by means of paint-brushes. For plain surfaces a *ground brush* of suitable size is dipped into the paint, taking up a moderate amount, and any superfluous paint is wiped off against the sides of the pot. The brush is held at right angles to the face of the work, so that the ends of the hairs force the paint well into the pores, and the brush must be applied vigorously. Work is usually begun at the top, and brought down, and in painting panelled

work, such as doors, the frames are usually first dealt with, then the panels. When paint is applied to the edges of any object, such as a door, in order to avoid an excess of paint at such points the brush is drawn a little away from the edges in working. Mouldings are particularly liable to collect excess of paint, and for such work it is used somewhat sparingly. When two or more colours have to be used it is necessary to take care that the edges of the colour last applied are very carefully cut in a true straight line to avoid irregularities; so also where painted work has to be finished against some other substance, as, for example, when sash-bars in a window are painted it is a sign of poor workmanship if the glass itself is smeared with paint where it adjoins the bars.

Preparing Surfaces. Before applying paint to any surface it is necessary to see that it is perfectly clean and free from grease, otherwise the paint will not adhere. It is desirable in the case of woodwork that the wood should be dry, for any moisture will be imprisoned by the coat of paint, and will not be able to dry out later. In the case of resinous woods any knots showing on a surface to be painted must be dealt with, or they will be liable to exude turpentine, and damage the work, and this process is described as *knotting*. Knots may be killed by painting with hot lime, and, when this is dry, ironing them with a hot iron and finally rubbing them smooth with pumice-stone; or the lime may be scraped off after twenty-four hours, and the knots painted with a mixture of red and white lead and linseed oil; and when this is dry the pumice-stone must be applied. It is a quicker and more usual process to cover the knots with a material termed *knotting*. This is usually *patent knotting*, a mixture of shellac and naphtha, which dries in a few minutes, leaving a protecting skin. *Red lead knotting* is also used, and is made by grinding red lead in water and mixing it with strong glue. This is applied hot, and dries in a few minutes. If, in spite of such treatment, knots still show through after the third coat is applied, they may be covered with gold or silver leaf, fixed on with size.

Priming. *Priming* is the first coat of paint applied. For woodwork it is usually formed of white and red lead mixed with raw linseed oil. A little litharge ground in turps may be added as a drier. This coat is intended to sink well into the pores of the wood and to fill them up, while at the same time the red lead hardens and forms a surface for the succeeding coat.

Clearcolle is sometimes used, but does not enter the pores, and may peel off; it should only be used for internal work, and then only if the surface has become greasy or dirty, and will not take the ordinary priming.

Stopping. *Stopping* is done with *putty*, which should be made from dry whiting kneaded up with raw linseed oil, and with the addition of a little white lead. It is applied with the stopping-knife to fill any holes in the wood. The stopping hardens in the holes, and forms an even surface for painting. In the case of coloured woods to be varnished or polished the stopping may be tinted to match the wood. Stopping should be done after priming, or the oil in the stopping will be sucked out of it by the wood.

Subsequent Coats. If the work is to be finished white or a light tint, all subsequent coats must be kept light, or they will not be fully covered by the final coat; but if the finish is to be dark the earlier coats may also be dark, and are usually of a different tint to the final coats. The reason for this is that if all the coats were of the same colour parts of the work might be easily overlooked in applying one of the coats.

The priming coat is well rubbed down with sand-paper, glasspaper, or pumice-stone before the next coat is applied, and each subsequent coat, when it is dry, is examined, and any irregularities rubbed down.

Flatting. When it is desired entirely to avoid a glossy surface in the finishing coat—and this is often a desideratum—the previous coat is mixed with a larger proportion of oil than it would ordinarily have, and the final coat is mixed with turps only. It should be applied before the previous coat is quite hard, and dries without any gloss. Such a coat will not stand washing like a coat mixed with oil, and to overcome this a little size or raw oil that has been bleached is added, and this is termed *bastard flatting*.

Graining and Varnishing. This method of finishing paint is much less used than formerly. It is more expensive to execute, but, if well done, it will wear for many years if carefully treated and given a coat of varnish from time to time. The reason for its disuse is mainly an æsthetic one—namely, that it is confessedly a sham, and that it is more artistic to treat work that is covered with paint frankly as a painted surface, and not to attempt to make it resemble a costly wood. This method, however, for office work and for the offices of good houses, is so durable and useful that it is never likely to be abandoned entirely. For work that is to be grained the priming and two or three colouring coats are laid on as usual, and the ground is then prepared of the general colour of the wood to be imitated, and this is allowed to dry. The painter then mixes in a palette colours similar to the darker grains of the wood, and these are laid over the ground, and, while still wet, painters' combs [16] are drawn over it to give the effect of graining. For fine work camel-hair pencils may be used, and the effect of knots is produced by using sponges or pieces of cloth. This work requires considerable skill and practice if the graining of highly ornamental woods, such as maple and walnut, is to be faithfully represented, but a common class of graining can be executed without much difficulty.

Overgraining consists of applying a thin extra coat of raw umber or vandyke brown, mixed with small beer, over the ordinary graining. This is applied with a large flat brush with a wavy motion, and is intended to represent the effect of silver grain.

The varnish is applied after the graining is dry, and should consist of two coats of copal varnish.

Painting Iron. The surface of the iron must be clean and free from rust, and it is often usual to paint iron with one coat directly it leaves the forge or cast. It is customary to employ red lead or an oxide of iron paint. Ironwork should have another coat of paint before fixing, and, where exposed, a total of four coats. In painting rain-water gutters and heads, both the inside and the outside must be painted. In the case of ironwork that has been dipped in Dr. Angus Smith's solution, a coat of knotting is required before painting.

Repainting Old Work. Old work requires to be thoroughly cleaned before repainting; it must be well washed with soap and water, and afterwards rinsed with clean water, and rubbed down with pumice. The first coat of new paint should be mixed with a liberal supply of turps. If the old paint is worn in places so as to expose the joinery, it must have additional coats of paint over such parts; these are first executed and

allowed to dry, and the final coats carried over the whole uniformly. Where joinery has been repaired with new woodwork, this must be treated as new joinery—primed, stopped, and two coats of paint applied. This is described as *bringing forward*, and the final coats are taken over old and new work alike. If old paint has perished or become blistered so that it is impossible to make a good job by painting over it, it must be removed ; on iron this is done by scraping, and on woodwork by burning off, a jet of gas or the painter's torch being used against the paint, which is thus softened and easily scraped off. A solution of equal parts of soda and quicklime may also be used; the soda is dissolved in water, the lime added, and used hot with a brush, after which the paint can be washed off with hot water. If this is used the wood should be washed over with vinegar before repainting to kill the lime.

Varnish. *Varnish* is a transparent material which may be applied to natural surfaces or to surfaces already painted. Varnishes are solutions of resins or gums dissolved in spirits or in oil. Resin is the residue obtained by distilling turpentine. There are several varieties of resins, and some of them are termed *gums*. These are exudations from trees, and are, when first produced, mixed with some essential oil, which, evaporating, leaves a hard substance.

The principal resins in use for varnishes are as follow. *Amber*, obtained from Prussia, very hard and durable, but difficult to dissolve, expensive, and a slow drier. *Copal*, obtained from the East and West Indies and America, may be obtained in three different qualities, depending on the colour, the lightest being very pale, and used for high-class work. *Mastic* is a resinous gum obtained from the countries bordering on the Mediterranean. *Gum Dammar* is obtained from the kawrie pine, is rather soft, and almost colourless. *Lac* is a resinous substance obtained from the East Indies; from the natural substance *shellac* is manufactured, which is very pure, and is used in making lacquers. *Sandarach* is a somewhat similar substance, obtained from the juniper. *Common resin* is either brown, which is formed by distilling the turpentine of spruce fir in water, or white, which is distilled from Bordeaux turpentine.

The *solvents* (which correspond to the vehicles in paint) are *boiling linseed oil* used with the hardest resins and gums. Varnishes made with oil are the hardest and most durable, but take longer to dry ; they are used for superior work, and should be employed for external work. *Turpentine* is used with softer gum such as mastic, dammar, and common resin. These varnishes are less costly, and dry quickly, but are not so durable as oil varnishes.

Methylated spirit is used with lac and sandarach. These spirit varnishes are known as *lacquers*, dry quickly, and become hard and brilliant, but are apt to crack and peel, and are used mostly for cabinet work not exposed to weather.

Water is used hot with lac and with as much ammonia, borax, potash or soda as will dissolve the lac. This is inferior to the other varnishes. *Driers* are used with varnishes, and accelerate the drying, but if used in large proportions injure the durability. The usual driers are *litharge, sugar of lead*, or *white copperas*.

Work of a porous nature such as wallpaper or wood must be sized before varnishing, and no second coat of varnish should be applied till the coat below is thoroughly hard, or the drying of the lower coat will be stopped.

Staining. Stains are applied to light-coloured woods that are to be varnished. In some cases the colouring matter is mixed with the varnish, but it is usual to stain the wood with a liquid water-stain, then to size twice, and in good work to varnish the surface twice. In the case of floors, the margins of which are often so treated, the varnish is very apt to wear, and instead of varnishing, the work may be wax polished. The polishing is done with beeswax shredded, mixed with turpentine, and gently heated; the wax is applied with a rag and then vigorously rubbed with a cloth or, if a large area is dealt with, by a floor polisher. This work must be kept in good order by rubbing over about once a week, and maintains a better surface than varnished work, but demands more attention. The stains are supplied in various colours, to imitate different classes of wood, such as rosewood, walnut, oak, mahogany, etc., and also in other colours, such as green ; they may be obtained in a liquid state ready for use, or in powder, which is dissolved in hot water for use ; it is laid on with a brush or sponge in one or two coats, according to the colour required, and allowed to dry before sizing.

Applying Varnish. Care and judgment are required in varnishing ; the material is sensitive to atmospheric effects and should not be applied when there is much humidity in the atmosphere : newly varnished work must be protected from cold draughts. The varnish, until used, must be stored in a warm place and not become chilled: varnish should not be mixed with any other kind of varnish nor thinned with oil. The varnish is applied with a varnish brush, and is usually applied across the work and finished by stroking the work down with the brush in a vertical direction to make it flow and obliterate brush marks. Care must be taken not to apply too much varnish, especially at the angles, or it will run and form tears.

Whitewashing. This term is properly applied to the whitening of internal walls and ceilings with a mixture of whiting and water mixed with size, but is also sometimes used for the covering of walls with a mixture of lime and water, which is more properly described as *lime-washing*. Lime-white and common distemper are often applied by the plasterer, but will be described here. *Lime-white* is made from pure chalk lime mixed with water. Factories and other buildings are required to be lime-whitened at regular intervals, and the material for this purpose should be applied hot. The lime is first slaked, and, when slaking is complete enough, hot water is added to dissolve the lime; 1 lb. of pure tallow may be added to each bushel of lime or 4 lb. of sulphate of zinc and 2 lb. of common salt. Lime-whiting is also applied to the walls of cellars and similar offices. It is cheap, but will not withstand wet, and is liable to rub off, but is serviceable when it is desirable to renew a coat at short intervals of time.

Whitewash is made with *whiting*, which is white chalk finely powdered, and is sold in the form of balls. The balls are roughly broken, soaked in water, and stirred and broken up with a stick, or by hand, and left just covered with water for about six hours ; afterwards double size in the proportion of 1 quart of double size to 6 lb. of whiting is added and the mixture left to stand in a cool place till it becomes a jelly; then it is diluted and used. One pound of jelly will cover about six superficial yards.

Size. *Size* is liquid glue prepared by boiling down the horns and sinews of animals ; *double size* is the same material, but boiled down to about half the bulk, and is therefore stronger ; both these forms require soaking before use. *Patent size* is a

preparation of gelatine, and can be used without soaking.

Clearcolle is a coat of size mixed with water, which is laid over plaster walls and ceilings before whiting or distemper.

In mixing whiting for ceiling work some colour is mixed with it to counteract the yellow effect of pure whiting. This is termed *breaking down*—a little ultramarine or indigo, or sometimes black, if a dead white is required, but with tinted walls a warmer tone may be preferred for the ceiling, and a cream colour may be formed by adding ochre.

Distemper is formed of whiting and size with the addition of colouring material to produce any desired tint; the pigments are the same as used for oil paints, and are mixed with the whiting before the size is added. All distempers appear much darker when wet than dry. The real tint of any colour as mixed should be judged by applying some of it to a piece of white paper, and drying it artificially.

Washable distempers are specially prepared and sold in the form of paste; they require diluting with water before use, and must be mixed in accordance with the instructions given by the manufacturers. They may be obtained in a great variety of tints and colours, and form a good solid surface, which will stand washing.

Applying Whitewash or Distemper. This is done with a large brush [13] with a long wooden handle. The brush is dipped well into the pail of whitewash, and any superfluous material squeezed off against the edge; the brush is then applied smoothly and evenly to the work. The distemper should be stirred from time to time with a stick, and work should not be gone over twice.

Stencilling. Very good effects may be produced by stencilling a design on a plain coloured surface to form a border or line or to cover the surface generally. The pattern is cut out of a thin plate which is also provided with guides to indicate exactly the position it must occupy when shifted. Stencils may be comparatively simple or elaborate. Sufficient substance must be left in cutting the stencil to keep all parts of it connected together, and these ties should form an element in a good design. The stencil is placed against the finished surface of the wall, and a stencil brush [14] is dipped into the colour, which is darker than the ground, and is dabbed gently and evenly over the whole stencil. It must be held at right angles to the surface or the colour may run under the stencil plate and spoil the design. A design thus produced forms an excellent frieze to a plain distempered wall.

Tar and Pitch. Tar is obtained by the slow combustion of resinous woods, and such tar is known as *Stockholm tar*, as it was formerly almost exclusively imported from Sweden; it is thinner than coal-tar and of a rich brown colour, and penetrates well into the pores of the wood.

Coal-tar is a by-product of gas-making, and is formed by the distillation of coal; it is quite black in appearance and thick.

Pitch is the solid residue obtained by distilling tar; the process varies somewhat according to the nature of the wood from which it is obtained. Pitch may be added to coal-tar in the proportion of from 1 to 2 lb. to each gallon of tar. The object is to prevent the tar from running under hot sunshine, and, if used pure, it is apt to do so; a little lime is sometimes added with the same object. Pitch may also be added to Stockholm tar, but will destroy the bright, clear colour and make it nearly black, which is a serious objection if used for ornamental timbering in half-timbered gables and similar situations. Tar is applied hot, with a long-handled brush, and is principally used for timber work, especially fences and out-buildings much exposed to the weather, but is sometimes applied to exposed walls to render them waterproof.

Tar is also applied sometimes to rough ironwork, and forms a durable covering. Two coats should be used, and a little lime or sand may be mixed with it, and worked on with a hard brush.

Tar paint is used for some iron structures, such as bridges; the best mixture is said to be ½ lb. sulphate of lime, 1 gallon coal-tar, and sufficient naphtha to make it work freely.

GLAZING

The work of the glazier consists in cutting glass to fit openings of various sizes and shapes and in fixing it into frames of wood or iron, and sometimes into openings of brick, stone, or terra-cotta. and the making up of designs in small pieces of shaped glass termed *lead lights* and fixing them, and of similar work.

The glazier's tools consist of a *diamond* [28], which is used for cutting glass. This is a small uncut diamond set in lead and mounted in a brass ferrule with a hardwood handle. *Compasses* provided with a socket on one leg into which the handle of the diamond can be fitted for cutting circular work. *Hacking-out knife* [29], often a broken table knife, sharpened on the edge, and used for cutting out old putty in reglazing.

These are the principal special tools; but several others are used, already described in other trades —*square, straightedge, rule, claw hammer* (for sprigging), *stopping knife* (for stopping in and smoothing off putty), *dusting brush, sash tool* (for priming sashes, painting putties, etc.), and, in lead glazing, *copper bits* or *soldering irons*.

Composition and Forms of Glass. The ordinary glass used by the glazier is composed of a mixture of pure sand, soda and chalk, and broken glass; these materials are melted at a high temperature and by various processes, and are then formed into sheets of convenient size and thickness for glazing purposes.

In all forms of glass large sheets are charged at a higher price per superficial foot than small ones, as the latter can often be cut from waste or breakages. Any glass that is required to be bent is charged at a special rate if bent in one direction, and a further charge is made if bending in two directions is required.

The principal qualities of glass in ordinary use are *crown, sheet glass*, and *plate glass*, which differ from each other to some extent in composition, but mainly in the method of their manufacture.

Crown Glass. *Crown glass* is blown by means of a blowpipe into a globular form, then heated and rapidly rotated until it whirls out into a flat disc or *table*, in the centre of which is the *bullion*, or blob of glass, by which it was held. and which is thicker than any other part; but the thickness throughout is somewhat uneven, the centre part of the table being thickest; the size of good glazing panes is therefore limited by the diameter of the plate, which generally varies from 3½ ft. to 5 ft. The sheet may be cut up in a variety of ways, but the centre is cut out separately, generally about 5 in. square, and is known as a *quarry*, a term that is also applied to glass cut up into small pieces for lead glazing. The rough centres were formerly used for the commonest glazing, but in recent years have been in great demand for some forms of lead glazing. The maximum size of a

sheet of crown glass does not exceed 5 superficial feet, and the thickness varies somewhat. The weight is about 13 oz. to $\frac{1}{16}$ in. of thickness, and, for window glazing, should be about 16 oz. per foot. The glass is sold either in crates of tables containing half tables, semicircular in form, or in crates of slabs cut to sizes. This glass is very clear and white, but the surface is considerably curved unless specially flattened, which makes glazing difficult, and it can be used only for frames of a small size. There are several qualities—*selected qualities*, for glazing pictures, of which A is the best and B the second; ordinary glazing qualities, divided into *bests*, *seconds*, *thirds*, and *coarse*.

Sheet Glass. *Sheet glass* has to a great extent superseded crown glass for most purposes. It is blown in the form of a hollow cylinder with closed ends; these are cut off and the cylinder is cut throughout its length and afterwards reheated, when the glass falls outwards into a flat sheet, rectangular in form, and is gradually cooled. The surface may be polished or ground, and the glass bent to curves if required. This glass is made quite clear, known as *crystal* or slightly tinted; it is to be had in the same qualities both for pictures and glazing as crown glass; it is usually described by its weight per superficial foot; the usual weights and thicknesses are as follows: 15 oz. $= \frac{1}{16}$ in.; 21 oz. $= \frac{1}{10}$ in.; 26 oz. $= \frac{1}{8}$ in.; 32 oz. $= \frac{1}{7}$ in.; 36 oz. $= \frac{1}{6}$ in.; 42 oz. $= \frac{1}{5}$ in.

This glass is not quite so clear or white as crown glass, but it can be obtained in much larger panes, because the sheets, being rectangular and having no bullion, can be cut with much less waste. In all glass some small air bubbles are formed; in sheet glass and in the forms of plate glass prepared from it, these small bubbles have an oval or elongated appearance, the result of the process of manufacture; whereas, in cast plate, hereafter to be described, the bubbles are perfectly globular.

Plate Glass. *Patent plate* glass, or *blown plate*, is produced by polishing sheet glass on both sides, and is generally formed of the thicker qualities. The polishing of glass is done with sand, emery powder, and calcothar, or red oxide of iron. It is obtainable in two colours, ordinary *crystal* and *extra white*, and the qualities are known as *best*, "B," *second* or "C," and *third*, or "C.C."

Fluted sheet is formed from the third quality of glass by rolling it while hot with rollers formed with corrugations; the effect is to toughen the glass and to abolish its transparent quality without greatly reducing the amount of light that will pass through it. Such glass is used where privacy is required, and effectually prevents those outside a room seeing into it even when a light is burning inside.

Plate glass, or *British plate glass*, is made by pouring the molten glass on to an iron table and rolling it with heavy iron rollers, which strengthens the quality of the glass. It is made in the form of *rough cast plate*, *rolled plate*, and *polished plate*.

Rough cast plate is the commonest form of plate, and can be obtained in sheets of large size; its thickness varies from $\frac{1}{4}$ in. to 1 in., and it is very strong, but the surface is somewhat wavy. It is used for forming the risers of steps, and for glazing windows near the ground level where protection is essential, and for pavement lights. It is the cheapest form of plate, and is made in one quality only.

Rough rolled plate was patented by Messrs. Hartley & Co., and is often known as Hartley's rolled plate. For this glass the iron table on which it is rolled has the surface covered with fine lines or flutes formed on the surface, and these are impressed upon the glass when it is rolled out; the rollers are smooth, and one side only of the glass is thus fluted, but the other side is somewhat wavy. *Plain* glass is rolled with very fine parallel ridges close to each other. *Fluted* has ridges wider apart, the small fluted having usually eleven flutes to the linear inch, and the large fluted four such flutes. Glass can be obtained up to 10 ft. long and 3 ft. wide in this form, and it is rolled in the following thicknesses: $\frac{1}{8}$ in. weighing about 32 oz. per square ft.; $\frac{3}{16}$ in., $\frac{1}{4}$ in., $\frac{3}{8}$ in. This glass is much used for skylights, conservatories, and in windows of factories, etc. Light admitted though it is somewhat diffused, and the glare of sunlight is diminished, but more light is obstructed by this quality of glass than by polished glass; in fixing, the smooth face is usually placed outside.

British polished plate is cast in the same way as rough cast plate, but a superior quality of glass is cast for polishing, and it is afterwards ground down to an even surface and then polished on both faces. This glass is prepared in several qualities—*silvering quality*, specially intended for mirrors, but used also for the highest quality of glazing; *best glazing*, and *ordinary glazing*. This glass can be obtained in sheets of immense size, though very large sheets are charged at a special rate; but sheets up to 100 ft. area are usually kept in stock in several thicknesses. This glass is very clear and colourless, it transmits a greater proportion of light than any other material, and, in common with all forms of plate, is very strong; if $\frac{1}{4}$ in. thick, it prevents cold from penetrating to a great extent; it tends also to prevent burglary, as it cannot be cut and removed without noise.

Of *diamond and quarry* rough plate the former has one smooth side, while the latter has diagonal lines forming lozenge-shaped figures filled in with narrow ridge lines. The diamonds in the quarry plate are larger than in the diamond plate.

Figured Rolled Glass. There are various other methods of treating glass surfaces by rollers, which are of more recent introduction. But in all cases the method of production is somewhat similar, and the glass varies in appearance with the design cut upon the iron tables or upon the rollers. Of these forms of glass, one of the best known is *Muranese*, which is entirely covered on one face with small flutes, not parallel, but arranged somewhat after the pattern of a shell, in various shapes. This may be obtained in white or tinted glass. Another similar glass is known as *Arabesque*, and this also is formed with radiating grooves. Other forms are rolled, which are foliated in character, such as the *Japanese* pattern, in which flowers and foliage are represented on a ground covered with dots in place of grooves, and the *Flannel Flower* pattern, which differs in design, but resembles the Japanese in treatment. The object of all these forms of glazing is to destroy the transparency of the glass with as little damage as possible to its translucence, and they are generally employed for glazing windows and screens to rooms in which observation from outside is to be avoided.

Wired Glass. This is ordinary glass, but has imbedded in its thickness a layer of wire netting. The glass surface may be treated either as cast or rolled or polished. The special advantage of the wire is that in the event of the glass being broken by accident or by fire, the fragments are bound together by the netting, and will not fall out. It further increases the resistance of such glass to the attacks of burglars. The wirework is, of course, visible, especially in the polished glass, and this may

make it undesirable to use for such positions as shop fronts; but for skylights, and in other positions in which the presence of the wire is not objectionable, it is very serviceable. It may be obtained in lengths up to 100 in., and up to 36 in. broad.

Glass ventilators are sometimes used; these may either be cast with perforations in them, or the perforations may be cut afterwards. This is the most satisfactory plan, as such a ventilator can be cut where desired in a large plate; a circular disc of glass, with similar perforations may be fixed over it so that it will rotate on its axis and form a hit-and-miss ventilator [**31**].

Glass Shelves. Thick pieces of glass are often employed for shelves in operating rooms, for carrying instruments, and also in high-class shops. In such work the edges of the shelves are slightly rounded and also polished, and it is usual for all good qualities of glazing to have the edges of the panes rounded and polished in a similar way. The surface of polished plate, if it becomes scratched, may be repolished.

Cut Glass. Plate glass may be ornamented by cutting the surface so as to form a floral or foliated design. This cutting includes bevelling the edge, which is sometimes introduced and is effective, and also ornamental lettering. The surface is cut by means of an emery wheel, and afterwards polished. The wheel revolves on a stationary bed, and the glass must be brought into contact with it whenever any cutting is required. In order to do this, the sheet of glass is mounted in a frame and balanced with a counterpoise; it is then moved by the workman so that the cut is made of the desired size and shape. The cost of cutting is higher for the same amount of work on a large pane than on a small one, owing to the increased difficulty of manipulation.

French embossing is also executed on plate glass; in this work, the surface of the glass, excepting those portions which are to be embossed, is covered with Brunswick black; the surface is then subjected to the action of fluoric acid, which eats away the unprotected surface, giving it a dull, slightly opaque effect. The action of the acid may be stopped in certain parts of the design at any time by painting them out, and in this way some portions are more deeply eaten than others, affording a further contrast with the plain glass. The effect may be still further heightened by combining embossing and brilliant cutting in the same piece of glass.

Cloisonné glass is a somewhat recent form of ornamental glass which is very suitable for many purposes such as screens; it may also be used for external windows. It is prepared as follows: a sheet of glass the exact size required for the opening is taken, and the design selected is formed on the surface with a fine brass or gilt wire; the surface within each enclosed area is filled in with glass in small granules, which may be varied in size, and also in colour; either delicate or bold effects may therefore be produced. These granules are fixed with a transparent cement, and the whole surface of the glass is covered with the design, and this surface is afterwards covered with another plain sheet of glass, secured at the margins, and the sheet can then be fixed like ordinary glazing. The surface on both sides is that of a plain sheet of glass, which is cleaned perfectly easily. The most splendid method of treating glass surfaces is by staining or painting them, but this is work of a highly artistic character, and cannot be dealt with in this article [see page 4945].

Coloured Glass This may be produced by adding various metallic oxides and other substances to the materials used for making the glass before using, and a great variety of colours and tints may be produced in this way. The term *pot metal* is applied to glass in which the material is coloured right through. *Flashed colours* are those in which plain glass is covered on one side with a thin layer of coloured glass. A design may be formed on such glass by eating off the coloured glass in certain portions by means of fluoric acid, and allowing the white glass to show through.

By using pot metal as the ground work for flashed glass, an endless variety of tints and shades may be produced. Glass of this character is used in the making of glass mosaic, and for such work the gold cubes which are often employed may be formed by laying gold leaf on the plain glass and flashing a coloured glass over it; by changing the tint or colour of the flashing great variety and beauty is given to the gold underneath it.

Coloured glass is much used for ecclesiastical work, and is often called *cathedral glass*; where it is desired that such glass should not be quite transparent, it is sometimes slightly or considerably obscured by sprinkling over the sheet, while still quite hot, some fine sand, which becomes partially fused and incorporated with the glass, and forms a series of spots on the surface, which may be some distance from each other if lightly sanded, or close together if heavily sanded.

Transparency of Glass. Even the most transparent glass will not allow all the rays of light that reach the external surface to pass through it, but some kinds of glass obscure or reflect much more light than others. The diminution of light caused by filling an opening with different qualities of glass, as compared with the same opening unglazed, is as follows: Of the total light received, British polished plate, ¼ in. thick, intercepts 13 per cent.; sheet glass, 32 oz. to the foot, intercepts 22 per cent.; rough cast plate intercepts 30 per cent.; rolled plate, 4 flutes to an inch, intercepts 53 per cent.

Glass is prepared in the special forms of *prisms* for certain glazing work; these are cast of the required form, and afterwards polished and made up into lights for use as pavement lights, stall boards, coal plates, etc. [**30**]. The manufacture of these lights is in the hands of special makers, and they are usually supplied complete in their frames, which in some cases, on account of their weight, are hinged and balanced with counterweights, if they are likely to be frequently opened. The object of all such prismatic glass is to deflect the rays of light reaching the inner face of the glass and to send the rays in a horizontal direction, or nearly so; by this means the back portion of rooms that would otherwise be very badly lighted may receive a greatly improved illumination. Glass is also manufactured with a series of small parallel prismatic projections on the inner face with the same object. In other cases reflectors are employed filled in with sheets of glass fluted on the face and silvered on the back to direct light in the required direction.

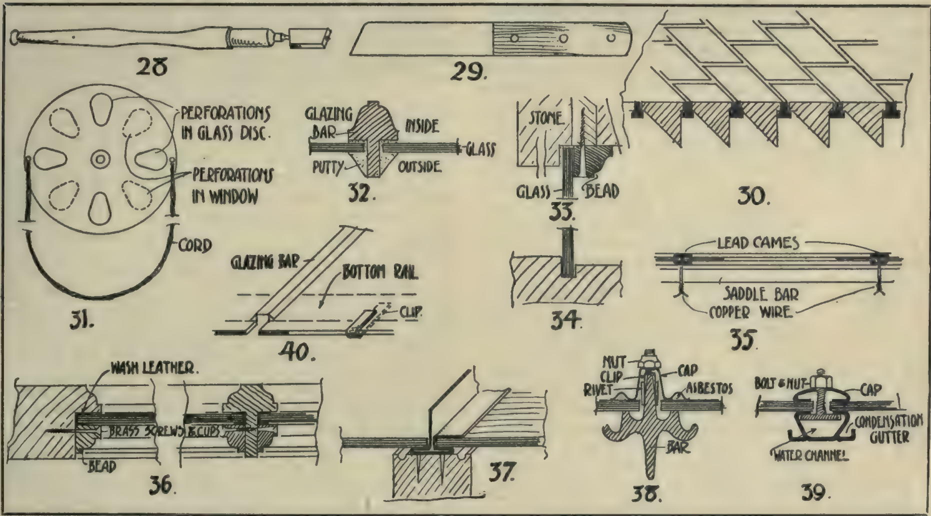
Glazing with Putty. For most glazing fixed in wood or iron frames, *putty* is used for fixing the glass to the frame. *Glaziers' putty* is made of whiting mixed with linseed oil and well kneaded; sometimes a little tallow or non-drying oil is added to it to keep it slightly soft, so that it shall not be damaged by the alternate expansion and contraction of the glass. When used, the putty is in a plastic condition, but somewhat stiff; the frame should have been at least primed, and if this has not been done, the rebate that receives the glass must be painted, or the wood would soak up the oil in the

putty before it had hardened. The glass is cut so as to fit somewhat loosely in the frame that is to receive it. If it were tight at any point, there would be a risk that the glass will split under the effect of expansion and contraction—if any slight settlement in the building should tend to alter the shape of the frame the same accident might occur—whereas, if it is slightly smaller than the frame the conditions suggested should produce no such result. The edges of plate glass should be blackened before glazing, to prevent the effect of reflection from them.

Puttying. The first operation is to draw or spread a thin layer of putty fairly evenly along the back of the rebate all round the frame; this is not carefully smoothed but left from the knife that is used to spread the putty. The sheet of glass is placed in the frame and pressed firmly against the putty on the rebate, which thus becomes reduced to a uniform thickness, and some putty is generally squeezed out in the process and will stand above the wood of the sash all round on the inside of the glass; this is not at once removed but left till it gets hard and is then cut off, generally after an interval of about a week.

If the sheet of glass is large and heavy it is very often *sprigged*; this consists in driving small brads of iron or brass into the woodwork at intervals, to hold the glass in position till the putty has hardened and is firm enough to hold the glass securely; but with panes of ordinary size, this process may be, as a rule, omitted. When the glass is in position additional putty is worked on all round the panes on the outside and finished with a sloping or weathered surface [32]. The external surface of the putty should be painted at once to prevent its drying too rapidly and cracking; a sash tool [11] is used, and care must be taken to see that the paint is not smeared on the glass.

Putty Glazing to Skylights. When putty is used for glazing skylights the system is similar: it is desirable when possible to employ a single sheet of glass to glaze each division of the light; the lower edge, or *tail*, is often supported by a copper clip [40] to give it additional security, and if two or more sheets of glass are used they must be well lapped and a copper clip may be used to support the upper piece. The extent of lapping will depend on the slope, but is usually about $1\frac{1}{2}$ in. The lower edge of the glass runs over the apron of the light and should be allowed to cover it completely; but in some cases it is stopped on the back of the apron, with the result that water is delivered on to the surface of the apron, and, especially if the inclination of the light is not great, this is liable to rot the wood. In glazing greenhouses and garden lights the glass used is generally thin, and is used in small pieces with several horizontal joints and a small lap; in such work the metal clips above referred to are not required. If ground glass is to be fixed with putty the surface round the edges should be first sized to prevent the putty from discolouring it.



GLAZING TOOLS AND SYSTEMS OF GLAZING

28. Glazier's diamond **29.** Hacking-out knife **30.** Prismatic glass **31.** Glass ventilator **32.** Glazing with putty **33.** Glazing in stone jamb **34.** Glazing in terra-cotta jamb **35.** Lead glazing with saddle-bar **36.** Glazing with wood beads **37.** "Simplex" glazing **38.** Helliwell's glazing **39.** Rendle's glazing

Glazing in Stone and Terra-cotta. In certain styles of buildings sheets of glass which are not required to open may be fixed in the stone or terra-cotta opening without the use of any wood or metal frame. This is usually done by forming a rebate in the frame, fixing the glass against the rebate and securing it in position with hard wood beads or mouldings screwed to wood or lead plugs let into the jambs [33]; the outer edge between the glass and the rebate is pointed all round in cement.

Where the glass does not consist of a single sheet but is in the form of a leaded light a groove is formed instead of a rebate in the material of the window opening, and the glass light can be slightly bent and placed in the groove and afterwards straightened out and fixed and pointed in cement [34].

Saddle bars are usually required for assisting to support lead lights which, in windows of any size, are not rigid enough to resist any considerable wind pressure. In the simplest form the saddle bar is a square bar of iron from $\frac{3}{8}$ in. square

upwards, depending on the strength required; the ends are fixed to the frame into which the light is fixed and the light is secured to the saddle bars with copper wire [**35**]. If the jambs of the opening are of stone or terra-cotta a mortise is cut in each side for the saddle bar and it is run in with cement; if a wood frame is used the ends of the bar may be turned up and flattened and perforated for a screw and then fixed to the frame.

In the case of very large lights, vertical bars or stanchions are used to stiffen the saddle bars, and are sometimes very large and strong and are secured to the surrounding masonry.

Glazing Internal Lights. Where glass is to be fixed in an internal screen or door, putty may still be used, but in such cases when there is no exposure to the weather it is not essential, and it is often preferred that both sides of a frame should have the same character and appearance; in such cases the glass may be secured in the rebate by means of small wood beads or mouldings fixed to the frame and glazing bars with small screws [**36**]: these should be of brass, and brass cups are usually provided and let into the beads to take the heads of the screws exactly. Such an arrangement allows of easy and quick repair to any pane that has been broken by merely removing the mouldings, inserting the new pane and refixing them. Where the upper panels of doors have to be glazed, the same system may be used, but a strip of washleather or vulcanised indiarubber is used for holding the edge of the glass to reduce the vibration due to the opening and closing of the door, which might otherwise crack the glass.

Glazing Without Putty. The drawbacks of putty are that the material does not remain permanently sound, but is apt to perish, especially in the case of skylights in which the glass is not placed vertically, but often at a very flat angle; this decay may be greatly retarded by careful painting at least in every second year, but in time putty is apt to crack, and ceases to be watertight. It is also a somewhat troublesome matter to hack out the old putty, which gets hard, and several systems have been adopted to avoid the use of any putty, but to provide for securing the glass in position by mechanical means; such a system must be, nevertheless, watertight, must not interfere with the expansion or contraction of the glass, and at the same time must render the execution of repairs an easy and rapid operation; it is essential that the construction be strong enough to allow of workmen getting about on the roof to execute repairs. The simplest form of this class of glazing is termed the *simplex* [**37**], and can be utilised with existing wood lights and bars by removing the rebates on the latter, or may in new work have bars specially prepared for it. The system makes use of a strip of lead specially folded so that it may be nailed to the top of the bar, and after the glass is put into position the edges are turned down and dressed over the glass. The lead strips are secured to the wood bars with copper nails placed on alternate sides of the centre line about 4 in. apart.

Rendle's Invincible glazing [**39**] has a specially formed bar of zinc or copper provided with condensation gutters, which is sufficiently strong for lengths under 4 ft., but for longer lengths must be carried on a bar of wood or a T-iron. The glass rests on this bar and a metal capping is employed, secured by bolts and nuts at intervals.

Hope's glazing has a specially moulded steel bar with a dovetailed groove in the centre of the top; into this a special cast lead cover strip is screwed with flanges dressed down over the glass.

Helliwell's Perfection glazing [**38**] also employs a special moulded steel glazing bar, with a capping of lead, zinc or copper, fixed with brass bolts and nuts.

Leaded Lights. *Leaded Lights* are formed of small pieces of glass fitted into grooved lead strips, which are soldered together to form lights or panels. The glass may be white, coloured, stained, muffled or rolled. The lead strips, or *cames*, are of an H section and are drawn, and the joints are soldered; the cames are cut rather short and drawn through a *compression vice*, the effect of which is to harden and polish the surface and to mill the groove; the centre between the grooves is the *heart*, and each of the sides is termed the *leaf;* this is usually flat or round, but may be beaded and is, for ordinary glazing, from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. wide, but may be as much as 1 in. The two leafs are opened out to receive the glass, and then a cement is brushed under the leaf, consisting of mastic or whiting and red lead, and the leaves are then closed down on the glass and coated with blacklead, or the surface may be gilded; they should be allowed a week to harden before fixing. The pieces of glass may be rectangular or of almost any desired form, but a piece of glass that is narrower near its centre than at its ends is undesirable as it is liable to crack across. The cames are bent to fit the outline of irregular pieces of glass, and the various lengths of cames are soldered together where they meet; short lengths of copper wire are also soldered in for fixing to the saddle bars already referred to. The cames often play an important part in the design of ornamental lights, and in all such work due provision for the saddle and stay bars must be made.

A more rigid method of fixing up panels from small sheets of glass has been, within recent years, introduced by the Luxfer Company. The pieces of glass are carefully cut and laid out on a table with copper ribbons till the panel is formed up of the requisite size. This is then put into an electrolytic bath and copper is deposited between the edges of the glass and intimately connects it with the frame, forming an extremely rigid panel.

Continued

OUR CONTROL OVER ILL-HEALTH

Digestion and Health. How We Hinder Nature's Work. Illnesses Arising from the Digestive System and How to Avoid Them

Continued from page 5702

By Dr. A. T. SCHOFIELD

NO system of the body is so grievously misused by its owners as the *digestive.* This is due first to the fact that it is more largely under our own conscious control than any other.

It may be well here briefly to review the limits of the conscious control of body operations, and we shall see how very narrow they are. The direct limits of the conscious mind and will are fairly well defined and generally pretty constant, though in some few individuals they extend further than in the majority; but under no circumstances can the will produce any direct organic change in the body.

With regard to the heart and circulation direct influence is very small. By conscious effort in very few people the heart can be slowed; and it is believed that there have been cases where it could be voluntarily stopped, though one cannot be adduced. We cannot consciously change the volume and course of the circulation, all of which is done constantly and with the greatest ease by the unconscious mind.

Over respiration we have greater power, and can vary it at will, within certain fixed limits. These limits exist whenever the life is imperilled or affected by want of oxygen, in which case the unconscious centres over-ride the strongest will, and force us to breathe, whether we will or no, so that our free will here is safely guarded. We have, of course, full control over the character of the air used, and this power we use to the full—in poisoning ourselves as much as possible with foul air and unventilated rooms.

Mismanaged Power. In the digestive organs, as we have already said, the will has in one way the greatest power. It is true that we have no control whatever over the food, once it is swallowed. In fact, as a rule, it then disappears wholly from consciousness; nevertheless we cannot all eat any sort of food we like, although we have absolute power over the quantity, so that we can starve ourselves to death or die from overeating. We can also voluntarily poison ourselves with alcohol to any extent. All these privileges we use to the full, and hence it is that this system suffers far more than any other, because here alone there are no limits to our powers of self-destruction. The unconscious mind does its best to neutralise the evils of our conscious efforts, but there comes a time when the food is so poisonous or insufficient or excessive that death, or at any rate, disease, ensues. The action of the bowels is also under our control, and this, too, we mismanage in every possible way.

The secretory system is beyond our direct control, save in the discharge of tears, saliva and urine.

In the spending of force by the *locomotive and nervous systems* we have great control, not in detailed actions, but in results. We have control over the special senses, and the upper portion of the brain only. All the lower part, concerned with the nutrition of the body, is under the sway of the unconscious mind.

Over the skin and its appendages, as regards its internal nutrition, we have no power, but we can and do damage and soil it to any extent externally.

Indigestion. Dyspepsia, or indigestion, is the most common form of digestive ill-health. The symptoms of it are a coated tongue (the tongue being the mirror of the stomach), a weight of pain after food, loss of appetite, dark rings under the eyes, and sometimes vomiting or purging.

Dyspepsia rises from four great causes, every one of them preventable, and it is for this reason, and this alone, that this information is given.

It is foolish to harrow people's minds with morbid descriptions of disease, which really concern no one but a doctor, and such will find no place here. But there are thousands of sufferers who have no idea that their complaints are *entirely preventable*, and can be cured by common-sense means, and it is for such that this course is designed. The four great causes of dyspepsia are excess of food, improper food, too rapid eating, and weakness of stomach.

The first cause is eating too much food. Up to twenty a person can hardly eat too much wholesome food. From twenty to forty he should eat meat only twice a day, as a rule, and after forty once a day, and should begin generally to live sparingly. A terrible excess of meat is eaten in England, which causes a common and dangerous poison—uric acid. Few who have not tried it have any idea of the comforts of living sparsely on plain food.

The second cause of dyspepsia is improper food—that is, very indigestible or decomposing, or badly or too richly prepared foods. Sometimes the food is very improper, such as green apples, raw potatoes, uncooked rice or raw spirits.

Too rapid eating is the third of these causes. Meals taken too near together, or eaten too rapidly, or when in a state of fatigue.

Weakness of stomach, the fourth cause of dyspepsia, may arise from nervous causes, poverty of blood, general debility or some local poison. These result either in feebleness of the digestive movements, or in poverty or scant supply of the gastric juice.

Preventable Evils. Practically all these causes are preventable. The simple remedies appropriate for them are first of all to seek out the cause, and, if preventable, to stop its action.

If this is beyond our power a doctor should be seen. If any special article disagree, it is well to see if the cooking of it is what it should be, and if so, to *eat less of it* rather than to discontinue it. Such indigestible combinations as tea and meat, rich sauces and twice cooked meat may, of course, be stopped. Rest after meals may help. Better mastication, slower eating, rest of mind at meal times and careful attendance to daily relief all greatly help. For flatulence, peppermint in any form with a little soda is still the best relief. For anything further a doctor should be consulted.

Biliousness. Biliousness is a digestive disorder, the cause of which is but little known. It is one of that interesting class of diseases that arises from self-poisoning, or, as it is called, *autosepsis.* It is not generally known that the body in the process of ordinary digestion eliminates from the food, and especially from nitrogenous foods, various potent poisons. Still more are made where the digestion is imperfect or the food improper or excessive, and it is one of the regular functions of the liver to purify the digestive products that pass through it on their way into the circulation.

When the liver is congested—that is, overloaded with blood from sudden chill of the surface by cold air or water—or when it has too much work put upon it from too much food, and especially rich meat foods, or when it is sluggish in its action for want of general exercise of the body and sedentary occupations, it fails to do its duty and allows some of the digestive products to pass into the circulation unpurified and containing certain poisonous substances.

These substances circulating in the blood at once begin to show their effects in the nervous centres, and all the signs of poisoning set in. The person feels very ill, and has a bad frontal headache. He refuses all food, and suffers from nausea and vomiting—often violently. By degrees the poison is eliminated and he recovers, for these attacks are seldom dangerous though most depressing.

It must be clearly understood that a bilious attack has nothing to do with bile; the disease that is connected with it is called *jaundice.* The former is a case of self-poisoning, arising from imperfect action of the liver due to preventable causes. No one ever really need have a bilious attack. The remedy is abstinence from food till it is over, and then nothing but light, digestible diet for at least two days after.

Vomiting. Vomiting is rather a symptom than a digestive disease; but as it often occurs apparently by itself we may treat it as such here. It is generally an effort of Nature to get rid of some poisonous or indigestible substance from the stomach, and in these cases it is wholly beneficial. It may, however, be due to at least two other causes. There may be *intense irritability* of the stomach, either from acute dyspepsia, some inflammation of the stomach, some pressure upon it, or the high temperature of fever that compels it to reject all sorts of solid food. Or the cause may not be in the stomach at all, but in the nervous system. There is *in the brain* what is called the *vomiting centre,* which, if irritated or pressed, causes vomiting. A simple remedy is to take one teaspoonful of chloroform-water every five minutes.

Stomach and Liver Diseases. Gastralgia, or pain in the stomach, again, may be due to some sore place in the stomach, such as an ulcer, or to the tenderness caused by inflammation, or other local causes. Or it may be a mere neuralgia, brought on by poverty of blood or weakness of nerves. In this case food generally relieves the pain; in the former it invariably makes it worse. By pain in the stomach is meant the stomach proper, not the whole abdomen, but just beneath the breastbone where the stomach lies. In simple cases a little bismuth often gives relief. If the pain be very acute, fixed and constant and accompanied by any vomiting of blood, this may be due to some ulceration, which may be serious or not, but it is always a matter for medical consultation.

Liver diseases are common in tropical countries, but are rarely severe in England. The most common trouble in this country is *enlargement of the liver,* from an overgrowth of fibrous material all through it, choking its ducts, and arresting its functions, due to alcoholic poisoning in its earlier stages. Then there is contraction, or *atrophy of the liver,* accompanied by *dropsy* or water in the abdomen, which is really a further stage, also caused almost invariably by alcohol. Here we get all the fibrous overgrowth that enlarged the liver in the first case contracting and strangling all its beautiful mechanism, so that not only can it not fulfil its functions, but the blood cannot actually get through it, except in very small quantities. The result is that the back pressure is so great that the watery part of the blood everywhere exudes through the walls of the abdominal vessels, and fills the abdomen with gallons of fluid, which as soon as it is removed is replaced by more.

Avoidable Ill-Health. Need it be pointed out that these conditions are wholly preventable, and are simply one of the results of the wanton misuse of our power over the digestive system? Surely sins are none the less heinous because they are against our own bodies, constantly wrecking and destroying the exquisite machinery by which life is maintained. In all cases of atrophy a doctor should be seen.

Congestion, overloading, and sluggishness of the liver generally results, as we have seen, in biliousness, which, indeed, also relieves it. A hot poultice over the liver or a hot bottle is another remedy.

One of the great functions of the liver is the production of *bile,* which is stored in a special vessel (the *gall bladder*) and discharged into the bowel as needed for antiseptic and laxative purposes. If the duct is blocked and the bile finds its way into the blood, the result is jaundice. In this disease, care should be taken against chills, and the diet should be simple and scanty, with daily relief till well.

We now come to a matter upon which it is necessary to speak plainly; and as this is a

serious medical work, one need have no scruples in doing so. The particular form of ill-health referred to is constipation.

This trouble consists in retaining in the body for an undue time those effete matters derived from the refuse of food and the process of digestion that are practically poisons to the system. These should be got rid of daily, and then no trouble arises. But if not, and constipation is allowed to go on, the ill-health that supervenes is often very grave, and of the most varied kind, though it is seldom traced to its real cause. We will indicate some forms of it.

How we Hinder Nature's Work. If the constipation be severe and prolonged, it may lead to absolute stoppage of the bowels. This, when complete, is fatal—no operation can save ; only death remains, which is all the more dreadful as it is wholly and completely avoidable. Short of this, there may be a partial blocking, which an operation can relieve. Appendicitis is occasionally the result of constipation.

But, setting these graver results aside, there are far more common forms of ill-health little suspected that are the constant result of ordinary constipation. We get a sallow or earthy complexion arising from the poisonous matter soaking through into the blood. With this goes a lowered condition of health, nutrition is impaired, the spirits and nervous system are affected, and the whole tone is altered. No name can be attached to the condition, but the effects are obvious, though the real cause is so often unsuspected. In some cases the results are far worse. There is solid ground for believing that many forms of *mental* trouble and disordered mind are really due to autosepsis. In other words self-made poisons have been absorbed into the blood, from prolonged constipation of a far more serious nature than those which cause a bilious attack. All who have experienced this will remember the profound depression of spirits that accompanied it, and will, therefore, be little surprised that, in a severer poisoning of the brain centres, worse symptoms should follow, and the reason itself be impaired.

Diarrhœa. This is the opposite state and much rarer, though when acute it may, at times, imperil life. It never poisons the whole system, however, like the other condition. On the contrary, it is generally the result of Nature's effort to get rid of some poison as quickly as possible. In a slight degree it need occasion no anxiety ; only if continuous and prolonged does it require treatment. It must not be forgotten that it is a symptom of English cholera, and also in many cases constitutes the first stage of typhoid fever.

These two diseases will be further spoken of later on. For simple diarrhœa, boiled milk and limewater, arrowroot with a little brandy, and sometimes a dose of castor oil will cure.

Dysentery and Enteric. We must speak of these diseases now, as they are not infectious fevers like others. Dysentery is a painful disease common in foreign countries where there are marshes or bad drinking water. It is a specific inflammation of the bowels, characterised by constipation, pain and much straining, often with much accompanying hæmorrhage. The trouble is that it generally leaves some bowel weakness behind it, with some liability of recurrence Unlike most digestive diseases we have hitherto considered, it is not entirely preventable in our present state of knowledge, though we may hope that with the researches and successes of the tropical schools of medicine this may soon be the case. In dysentery the diet has to be of pounded meat, milk and raw eggs.

Enteric, or typhoid, fever is a still more general inflammation of the bowels, and is characterised by pain and diarrhœa and general tenderness. It also often leaves after effects, though not to the same extent as dysentery.

Appendicitis. This famous disease is an inflammation of a very small and obscure corner of the digestive tract—the *vermiform appendix.* This relic, which hangs like a small worm from the end, or rather the blind end, of the large intestine in the right groin, and is about four inches long, has occasioned more interest and discussion than the whole of the rest of the bowel tract. This is due to the fact that besides any beneficent action its scanty secretions may set up in the bowel, it is, owing to its small size, a source of great danger. It is dangerous because it forms a convenient place for cherry stones, grape stones, orange pips, and small indigestible accretions to lodge, and set up ulceration.

The subsequent processes are so remarkably beneficent, and such an illustration of the protective action of the *vis medicatrix naturæ,* that we will briefly describe them in the words of Sir Frederick Treves. " In appendicitis a little trouble occurs in the appendix. The wall is perforated, and an acrid poison finds its way into the sensitive cavity of the abdomen. The symptoms that follow are termed the symptoms of peritonitis. They are distressing and urgent, but they are all benevolent in intent, and are the outcome of Nature's vigorous efforts to minimise calamity, and save the patient's life. It is, in every instance, a beneficial process. It is Nature's method of bringing about a cure, and is successful in millions of instances. But for it many such cases would be instantly fatal."

Peritonitis and Colic. Peritonitis may occur quite apart from appendicitis, and is an inflammation of the delicate membrane covering the bowels.

Formerly it was one of the gravest diseases ; now, thanks to antiseptic surgery, it is rarely fatal. The symptoms are exquisite tenderness over the whole abdomen, which is as rigid as a drum—both very protective symptoms.

Colic is the imprisonment of wind in some part of the large or small intestines, and the result is agonising pain, which, however, differs from all inflammatory internal pains in being made much better by pressure instead of worse. The pain also moves from place to place. Peppermint or a dose of chlorodyne will probably relieve the pain.

Continued

HOW ENGLAND LOST AMERICA

The American Revolution. Foundation and Growth of the United States. The War of Independence and the Alliance with France. George Washington

By JUSTIN McCARTHY

BEFORE the death of Soto French colonists had appeared in America, where they had to encounter the unceasing hostility of the Spaniards. The French were soon followed by English, whose way had been prepared for them by Hawkins, Drake, Gilbert, and Raleigh. The reported richness of the New World tempted many to try their fortunes there, and though the English had some terrible repulses, as at Roanoke Island, they were able, after the defeat of the Spanish Armada, to lay the foundations of successful colonies.

The Colonisation of Virginia. After Raleigh's fall in England his charter was given to the Virginia Company, called after the English possessions in America, which had been named after the virgin Queen Elizabeth. One of the divisions of this company had made an unsuccessful voyage to their territory of Virginia. The other division then fitted out three ships, the Good Speed, the Discovery, and the Susan Constant, under the authority of the new charter, which, among other conditions, included one stipulating for the supremacy of the Church and King of England.

The only men of note in this expedition were the commander, Christopher Newport, and Captain John Smith, who had led a most adventurous life, fighting as a soldier of fortune all over Europe. He had previously escaped from Constantinople after having been sold as a slave. He did much towards founding Jamestown, and at this time the romantic incident occurred of his capture by Indians, who were about to kill him. His life, however, was begged by Pocahontas, the daughter of their chief, who granted her request and set Smith at liberty. Years after Pocahontas was captured by the English, married an Englishman, and came to England.

The Beginning of the Slave Trade. The colony of Virginia did not flourish, and was only saved by the arrival of provisions from England. Sir John Dale, the governor, did much for the improvement of the colony by strict legislation. Its chief industry was tobacco, for which there was a growing demand in Europe, and for this cheap labour was so much wanted that in 1619 a Dutch ship sold twenty negroes to the settlers, thus laying the foundation of the Slave Trade. Felons from England were also shipped to America as slaves, and the kidnapping of people for the plantations became quite common. The colony of Jamestown increased, until there were eleven settlements or boroughs, from each of which two representatives were chosen, who met in the first representative assembly in America, called the House of Burgesses, on July 30th, 1600. The English Government pressed very heavily on the colony of Jamestown, depriving them of their legitimate liberties, until in the reign of Charles II. they deposed their governor, Sir John Harvey, who was much disliked, and the King was compelled to give way.

The Formation of American States. Up to this time education had been rather at a standstill in the colony, but in time printing-presses were introduced, and in 1692 the William and Mary College was founded largely for the purpose of providing clergy of the Established Church, which was the religion of the colonists. Some seventy years before this the colony of New England had been founded by the Puritans, who came over in the Mayflower and other ships. In spite of incredible hardships this colony had flourished from the beginning, and other colonists joined them and spread further afield. Boston began to crown its Triple Hill, and Salem and other towns came into existence. The New World increased rapidly, and the land was partitioned into divisions like English counties. The people of Massachusetts erected Harvard College, named after its founder. When Charles I. attempted to interfere with the liberties of the colonists, Boston armed itself strongly, and a similar attempt of James II. failed. The colonists had also to be ever on the watch against the Indians, with whom they were constantly at war.

The various States gradually took the names by which they are now known: Massachusetts, New Hampshire, Connecticut, Maine, Vermont, Rhode Island, were all a part of the union of the old thirteen. The Dutch had colonised Manhattan Island and called their town there New Amsterdam, but the English wrested this from them and after some vicissitudes the town was called New York, after James Duke of York. Pennsylvania, founded by William Penn in the reign of Charles II. in the south, Maryland, North and South Carolina, founded within a few years of each other, were soon in a prosperous condition. For the next hundred years or so the colonists had to contend against the ceaseless hostility of the Indians, encouraged and often commanded by the French. The French did their utmost to encroach on the English possessions, and it was as an envoy to them that George Washington, then only twenty-three, is first mentioned in history.

French Interference. Hostilities now began between the English and French, beginning disastrously for the English, who were defeated with great loss under General Braddock, a brave, rash officer who was killed in the fight. But fortune changed, and under Washington the English succeeded. Several minor victories

followed his first success, and the heaviest blow to the French was the capture of Quebec by General Wolfe, after a fierce fight in which Wolfe and Montcalm, the French commander, were both killed. This victory had the advantage also of discouraging the Indians in a deeply-laid scheme for the overthrow of the English, and, though there was war for about two years between the English and the Indians, it ended in the defeat of the red men by the white, and for a while there was peace.

But this peace was soon broken by the war with the mother country that was to make America a nation, and one of the greatest powers of the world. The English Government was very unfortunate in its treatment of the American colonies. Its chief knowledge of colonial affairs was derived from the governors, who were English and generally at variance with the people they governed. Thus the English had for the most part an erroneous impression of the colonists, and encouraged the Government in foolish acts of interference with popular rights which destroyed all sympathy between the colonists and the mother country.

The Effect of the Stamp Act. The Government, under George Grenville, determining to stop the wholesale smuggling carried on by the Americans, made itself much disliked by the colonists. It also determined to place garrisons all over the States, for the support of which it was proposed to tax the colonists by means of the Stamp Act, which provided that all legal documents should be written or printed on stamped paper to be sold by the Government. This act was so unpopular with the Americans that after innumerable appeals to the English Government, which passed unheeded, in 1765 they called a congress at New York, at which Massachusetts, South Carolina, Pennsylvania, Rhode Island, Connecticut, Delaware, Maryland, New Jersey, and New York were represented. This congress drew up resolutions setting forth the rights and grievances of the colonists.

But the Ministry in England had now changed, and the Stamp Act was repealed by the new Government. Unfortunately, however, England had not abandoned the attempt to tax the colonies, and it was decided that a revenue must be had out of America. The proposal to garrison the States also caused much friction, and the Legislature of New York refused to execute the Act by which the King's troops were to be garrisoned on them. Parliament therefore passed an Act restraining the New York Legislature from making any law until it had given way on this point. The Americans were firm, and, finding their appeal useless, determined to import no more English goods.

The Colonists and the Government. Great indignation was displayed over the seizure of an American sloop supposed to be contraband, and the English governor had to call out the military. The Government was alarmed at the firmness of the colonists, and it was proposed to repeal all the taxes except the one on tea. This, however, did not placate them, and an unfortunate fracas between some Bostonians and English soldiers, in which several Bostonians were killed, added to the estrangement of the two countries. The tax on tea was much resented by the colonists, and on the arrival in Boston Harbour of three shiploads of it, the Bostonians seized the cargo and threw it into the sea, an example which other towns soon followed. England was infuriated by this, and in 1774 it was decided to close the port of Boston to all commerce, and to deprive Massachusetts of many of its liberties, these measures being enforced by aid of the military. The Americans, determined not to give way, called a congress, at which all the States save one were represented. The Declaration of Rights was drawn up, protesting against this treatment.

Burke and Chatham in England proposed various measures in favour of the Americans, but these were rejected by the House of Commons, urged on by the King, who imagined that the colonists could be bullied into compliance, and it became plain that war was inevitable.

The War of Independence. The Americans fortified their towns, and drilled their men. The English General Gage, wishing to seize the stores and disperse a body of Militia at Concord, endeavoured to take the place by surprise at night; but a patriot, Paul Revere, got wind of the affair, and rode his famous ride, warning the colonists. So the English troops, under Colonel Smith, were themselves surprised, and forced to retreat to Boston with severe loss. Thus began the American War of Independence. Soon after this the second Continental Congress was called. It decided on various measures, the most important being the appointment of George Washington as Commander-in-Chief of the colonial army. Not long after the forts of Ticonderoga and Crown Point, in which were a large supply of stores and arms, surrendered to a party of patriotic adventurers; but troops under Generals Howe, Clinton, and Burgoyne now began to pour in from England, and the next engagement was not successful for the colonials. The Americans were eager to occupy Charlestown, and to this end it was determined to occupy Bunker's Hill—a height at the back of the suburb.

Bunker's Hill. One night a party of men crept out, and, in spite of the nearness of the British forces, reached the height, and erected fortifications; but in the morning they were discovered by the British, who attacked them, and after a terrible struggle, drove them from the position. Washington now took command of the colonial forces, and compelled the British under Howe to evacuate Boston. The English army sailed away in its fleet, and Washington, with Nathaniel Greene, David Morgan, John Stark, John Sullivan, Israel Putnam, and Henry Knox under him, marched to New York, where he believed the English had gone.

The Americans now determined to attack Canada. An army was sent there, which, after some success, was defeated in the attempt to take Quebec, and had to leave Canada; but the English were repulsed when they tried to take

Charlestown, and this success brought many waverers to the side of the colonists. In 1776, a committee of five members of Congress—Jefferson, Franklin, Adams, Sherman, and Livingstone—drew up a Declaration of Independence. This was discussed by Congress in the first days of July, and on the Fourth it was, with some slight changes, agreed upon and signed by the members of Congress. The news was received with joy by the people. The declaration announced that the United Colonies were free and independent States, and were absolved from all political allegiance to, and connection with, Great Britain.

The Sympathy of the French. Washington, who was at New York, had to contend against many difficulties. The city was largely loyal, but the army, weakened by disease, grew disheartened. In August they were attacked and defeated by the English, and in September Washington retired to New Jersey; and New York fell into the hands of the English. Washington's men began to leave him, and he sent in vain for help to other American commanders. He persevered, however, and when the Congress gave him almost unlimited power with regard to raising troops, things began to look brighter. The English gave a free pardon to all who would desert the American cause, and many availed themselves of it. But before the end of the year Washington was able to clear the Jerseys and force the English to retire to New York.

The Americans now decided to appeal for help to France, and Franklin, Arthur Lee, and Silas Deane were appointed Commissioners to plead the cause with the French King. Though they were at first unsuccessful, they were joined by the young Marquis de la Fayette, whose example was followed by such a number of men that France subsequently formed an alliance with the Americans, and in 1778 formally recognised the United States. Great assistance was given to the American cause by Paul Jones, the Scotch sailor, a captain in the United States Navy, who became the terror of the English coast, which he ravaged unmercifully. His most famous fight was that with two English warships off Flamborough Head, where, after a most bloody fight, the English ships surrendered.

The French Alliance. Meanwhile, in America the colonists were sustaining many defeats. Washington was defeated at the battle of Brandywine, and Philadelphia was occupied by the English, who also captured Redbank, thus opening the Delaware to their fleet. In the north Burgoyne had allied himself with the Indians, thereby deepening the hatred between the Colonials and the British. He had taken Ticonderoga, but, after many defeats, had to retire to Saratoga, where he was surrounded by the Americans and compelled to surrender on the condition that he and his army should return to England and not again serve against the Americans. The French now made a treaty of commerce and alliance with the Americans which was virtually a declaration of war on England. The English Government made some effort at peace, but the war continued. It was at this time that Benedict Arnold was discovered to be a traitor. Having been somewhat badly treated by Congress he entered into a treasonable correspondence with Clinton, the English commander. Arnold, who was commander of West Point, agreed to surrender this fortress to the English, the loss of which would, he hoped, so paralyse the Colonials that their cause would be lost, and the hated Congress overthrown. Major-General John André of the English Army visited Arnold within the American lines to arrange particulars, and, falling into American hands when departing to rejoin the English forces, incriminating papers in Arnold's writing were found on his person. He was tried as a spy and hanged, while Arnold escaped to an English ship.

The End of the War. The war continued with varying success for two years. Finally, Lord Cornwallis, the English commander, having shut himself up in Yorktown, Virginia, was there besieged by Washington, the sea being held by the French fleet. Famine compelled him to surrender on the terms that he should hand over his troops as prisoners of war to Congress, and his naval force to the French. This was the end of the war. Peace negotiations were opened in Paris, conducted by Franklin, Jay, Adams, and Laurens, on behalf of America. A treaty was concluded by the provisions of which the United States extended from the Atlantic coast to the Mississippi, and Florida was restored to Spain, which also retained Louisiana. Thus ended the nine years' war which brought into existence a new English speaking nation.

The next six years proved extremely critical for the United States. Though they were free, they still had great difficulties to contend against. Their trade was crippled, they were heavily in debt, they were torn by internal dissensions, and they seemed to be leaderless.

The First American President. But the new country was determined to overcome these difficulties, and in 1787 a great convention was held in Philadelphia, to which all the States except New Hampshire and Rhode Island sent delegates, among them Washington, Franklin, James Madison, Elridge Gerry, Francis Dana, and Alexander Hamilton. After much discussion, the convention succeeded in producing the Constitution under which, roughly speaking, America still lives. It was based on the legislative power of a Congress, consisting of a Senate and a House of Representatives, a new President to be chosen every four years. Washington was chosen as first President, and took the oath in New York on April 30th, 1789. In April, 1790, Franklin died, universally mourned. Washington, who was twice elected President, had great difficulties to combat, and made many enemies during his term of office, in spite of his untiring efforts towards the good of the country. At the expiration of his second Presidency he retired from public life, and died two years after.

Continued

PRECIOUS METALS & STONES

Gold and Silver Recovery. Refining and Assaying. British Coinage. Precious Stones. Imitation and Artificial Stones. The Diamond. Gold and Silver Work. Jewellery

Continued from page 5691

IN this article there is outlined the production of the precious metals in the conditions in which they are used in coinage and the industries, with their application therein, and the occurrence, properties, and uses of the precious stones which, in the artistic craft of jewellery, are associated with the precious metals. The methods of extracting, and the properties of the important precious metals, gold, silver, and platinum, have been dealt with in various preceding groups, particularly in Mining [pages 2375, 2380, 2665, 2959, 3769, and 3835], Materials and Structures [page 1396], Metals [page 4303], and in Chemistry [pages 1447 and 1448].

Occurrence. The ores of gold differ conspicuously from those of all other metals in the extremely small proportion of the metal sought to the amount of valueless material, or "gangue," accompanying it. Practically all gold deposits now worked contain not more than from one part of gold in from 70,000 to 100,000 parts. Gold is found in the metallic or native state (generally alloyed with other metals), and in combination with tellurium.

Native gold usually contains silver, and sometimes copper, iron, bismuth, platinum, palladium, or rhodium. Silver occurs, both free (mixed with gold, mercury, or copper) and in combinations which differ so considerably that the metallurgy of the metal is very complex. Silver is also a valuable constituent of galena, zinc-blende, most of the pyrites, and of some copper ores, though the percentage is very small (up to 1 per cent. compared with from 60 per cent. to 87 per cent. in the case of the ores).

Extraction Processes. Gold may be extracted from its ores either by simple washing (in the case of native gold) or by metallurgical processes, when it is amalgamated with mercury, or alloyed with lead, silver, or copper, or is brought into solution. The metal is obtained from mercury alloys by distillation; from lead or lead-silver alloys by cupellation; from silver or silver-copper alloys by solution in acid; and from weak cyanide or chloride solutions by precipitation with ferrous sulphate, charcoal, or zinc, or by electrolysis.

The Siemens-Halske electrolytic method is now largely employed. The double cyanide solution is electrolysed in iron tanks between lead cathodes and iron anodes, and the gold recovered from the cathodes by cupellation.

Silver is obtained from its ores by amalgamation, by the formation of a lead alloy, or by solution processes [see page 4303].

Amalgamation. Amalgamation, the combination of gold or silver with mercury, is the cheapest, simplest and most generally used method of extracting these metals. It is the basis of hydraulic gold mining [see page 2959], and of the stamp-battery process [see pages 3770 and 4303]. In Mexico the old processes of crushing and amalgamating gold and silver ores in *arrastras* (revolving stamp-mills driven by mules) and heaps (*patio* process) are still carried on. The processes are lengthy and wasteful of mercury, but they extract a greater percentage of metal than any other known method. Electricity has displaced mules in at least one Mexican mill.

In stamp-battery amalgamation the amalgam settles in the corners of the mortars, or on amalgamated copper plates on the inner sides of the mortar. The pulp escaping from the mill is made to flow over amalgamated copper plates to catch any free gold or amalgam passing over.

The amalgam is removed from the plates by means of blunt knives followed by scraping with pieces of hard rubber.

Purification and Filtration. The amalgam removed from the outside plates in a battery is usually clean and stiff enough to be retorted without any further treatment. But gold amalgam obtained from the inside of the mortar, and from the treatment of concentrates, etc., frequently contains sand, pyrites, and other impurities, from which it must be cleansed, while the gold amalgam produced in hydraulic operations, and all silver amalgams, contain excess of mercury.

In small mills the cleansing is done by hand-grinding the amalgam in a mortar with water until it is reduced to a thin liquid, a scum being obtained, which is skimmed off and reground with more mercury. In large mills mechanical clean-up pans are used. The Knox and Berdan pans are the two commonly used pans. The Knox [page 4304] is similar to the silver amalgamating pan, and acts on the principle of agitating the dirty amalgam with water, so that the impurities form a scum on the surface. In the Berdan pan, the pan, inclined at an angle, itself revolves, and impurities are washed over the lower edge by a jet of water, grinding being effected by a freely moving ball.

Excess of mercury is separated from the amalgam by filtration through a conical canvas or chamois leather filter-bag [1], supported on an iron stand, and holding about 12 cwt. of amalgam. The weight of the amalgam is sufficient to force the greater portion of the mercury through the bag. If, as is sometimes done, air pressure is applied, more mercury is expressed, but it is richer in gold or silver. Hand-squeezing of the filter-bag by twisting it in water contained in a mercury pan is still considerably employed.

The solid amalgam removed from the filters may contain from 20 per cent. to 22 per cent. of silver, or about 40 per cent. of gold, in the case of single metal amalgams, and from 30 per cent. to 45 per cent. of gold and silver, where, as is usual, both metals are present.

Retorting. Gold and silver are recovered from the amalgam by distillation. Two kinds of retort are used for this purpose—the pot-shaped [2], much used in America, and the horizontal cylinder [3]. The pasty amalgam is kneaded into balls or cakes. In the horizontal retort the balls of amalgam are separated by iron divisions or by the ash of sheets of notepaper.

Adherence of gold or silver to the sides of the retort is prevented by a layer of chalk or whiting, or by the ash of sheets of paper. The mercury is condensed in the usual manner by water-cooled tubes. The metal obtained is spongy and porous,

and varies from 500 to 950 fine in gold, the remainder being silver and the base metals. It is melted down with fluxes, cast into bars, and then becomes "bullion" ready to be refined. This is usually the termination of the mine works operations, and the bullion is sold to refiners for further treatment.

Preliminary Refining. Gold and silver alloy in all proportions so that practically all bullion contains both, and refining operations are conducted with a view to their ultimate separation, which is effected by "parting."

Base metals and other impurities are partly removed by a rough refining process at a preliminary melting of the bullion, but the extent of it is limited by the fact that the molten oxides formed rapidly corrode the crucibles. The crucibles used are of clay or graphite. The crucible is first raised to a red heat, a spoonful or two of borax is thrown in as a flux, and the bullion is then fed in by means of a hand shoot. If the bullion is of high purity only a very little sodium carbonate or nitre is added and the resulting slag is poured off with the metal.

But if it be base, partial refinement is effected by adding more borax and nitre, and also bone ash to absorb the oxides formed. If much lead is present sal ammoniac is added at intervals alternate with nitre. Antimony or arsenic are removed as iron salts by stirring with an iron bar, and using but little nitre.

One hundred years ago it was proved that when bismuth, lead, antimony, or arsenic are present in gold in proportions as small as $\frac{1}{1920}$ the gold is brittle and unfit for coinage. The further treatment thus sometimes necessary is called *toughening*, and is effected by converting the contaminants into their volatile chlorides, either by sprinkling ammonium and mercuric chlorides on the melt, or by forcing chlorine gas through it (Miller's process). The Mint chemist recommends the use of oxygen for toughening.

The charge is then rendered homogeneous by stirring with a red-hot annealed graphite bar. In the bottom of the ingot mould is placed a little non-volatile oil, which burns on the top of the gold and prevents tarnishing.

Electrolytic Refining. In electrolytic refining of copper and silver by the appropriate processes practically all the silver and gold, or the gold alone, are left in the anode slime, from which they are readily recovered. Gold, however, cannot be electrically separated from a cyanide solution containing silver, copper, etc., because these metals are co-deposited therefrom; but an electrolytic method devised by Wohlwill has been successfully used in Germany. The electrolyte is a hot acid solution of gold chloride, and a smooth deposit of gold, assaying over 99·9 per cent. pure, is obtained. All the foreign metals of the anode pass into solution, except those of the iridium group, which remain unattacked, and silver, which forms its chloride; platinum and palladium accumulate in the bath, being removed at long intervals by precipitation. The process is thus particularly appropriate to gold alloys of platinum.

Silver, over 99·9 per cent. pure, is electrolytically obtained by Moebius's process from cast crude anodes of doré silver in a half per cent. bath of silver nitrate made slightly acid. The cathode is an endless revolving band of thin rolled silver upon which the metal is deposited in a pulverent and non-coherent condition, and automatically removed by contact at one end with a moving belt. The gold is recovered from the anode slime.

Refining by Cupellation. As explained above, the rough refining operations included in the melting of the metal before casting are limited in extent, and bullion containing considerable quantities of contaminating metallic oxides must be treated to "cupellation," a process of great antiquity, by means of which pure gold or, more frequently, a pure alloy of silver and gold, is obtained. It is also the principal refining operation applied to the product of the lead-alloying gold or silver extraction process. Its principle consists in the fact that molten lead monoxide (litharge) dissolves any metallic oxide which may be in contact with it. The separation of the litharge solution of oxides, thus obtained, from the pure noble metals which do not oxidise is effected by taking advantage of the property of bone ash of absorbing molten litharge, including its solutes, while remaining impermeable to the unoxidised metals. In practice this is achieved by making a shallow vessel of compressed bone ash, called a "cupel," from well-burnt, sifted ashes of sheep or horse bones mixed with a small proportion of fern or pearl ashes, and moistened sufficiently to bind on pressure. An oval vessel [**4**] of from 4 ft. to 5 ft. long, and $2\frac{1}{2}$ ft. to 3 ft. wide, with a depth of about $2\frac{3}{4}$ in., may be used in large operations, with walls of from 2 in. to 3 in. thick, one end being made 12 in. or 13 in. thick. Frequently the bed of a reverberatory furnace itself is used, a layer of bone ash, or, more frequently in large works, a mixture of crushed limestone and clay, being placed thereon. The cupel is placed in a reverberatory furnace, and, when red-hot, molten bullion and lead are ladled in. The cupel soon becomes saturated with the litharge oxide solution which flows to the side, and an air-blast is then turned on to force the litharge towards the thickened end of the cupel, across the surface of which a channel is cut. The litharge runs over into an iron pot, more molten lead or lead alloy being added as litharge is removed. In this way six or more tons of lead alloy may be refined in one cupel. Only traces of the precious metal are carried into the bone ash by the litharge.

Although gold is not accounted volatile, volatilisation losses in cupellation may amount to 0·5 per cent. They are diminished by the presence of silver, and increased by copper. The cupels used are re-powdered and gold and silver recovered.

Parting. The final operation of separating the silver and gold is known as "parting." The old process of parting with nitric acid was known as "quartation" or "inquartation," because the alloy refined was made up to 3 parts of silver and 1 of gold. It is still the process used in assaying and is described in that connection; but it is not otherwise used on account of the cost of the acid.

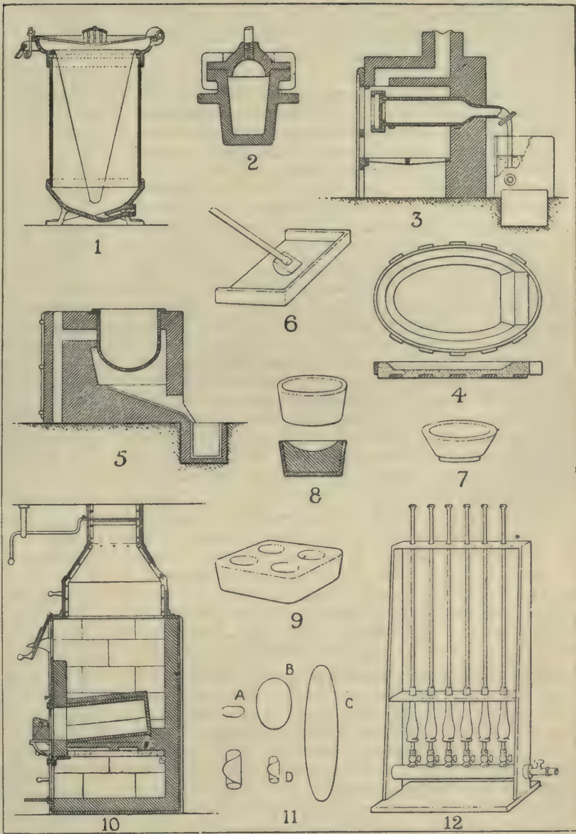
Sulphuric acid is now generally employed in large refining operations. Copper and silver are converted into their sulphates by hot concentrated sulphuric acid, while gold is unattacked. In this process the gold (and copper, if any) present must not exceed one-fifth of the total alloy; 80 to 95 per cent. of silver being required, and these proportions are made up, if necessary, by adding silver before cupellation or melting.

The alloy is granulated and boiled with concentrated sulphuric acid in a platinum, white pig-iron [**5**], or clay-coated porcelain vessel. When action ceases, a little weaker acid is added and the alloy again boiled. The liquid containing sulphates is then decanted off, and the gold (which may again be treated with acid) washed, melted, and cast into ingots. The gold thus obtained is 997 to 998 fine.

The acid sulphates liquor is poured into a leaden vat containing water and copper turnings, and heated. Cupric sulphate is formed, and the precipitated silver is collected, repeatedly washed, and cast into ingots. The sale of the by-products (copper sulphate and acid) more than covers the cost of the copper used. At San Francisco green vitriol (ferrous sulphate) is used for reducing the silver sulphate. It is also reduced by means of sheet copper.

The process of parting gold and silver by converting the latter into its chloride, suggested by F. B. Miller and largely employed in the Australian mints, is referred to above. The bullion refined by this method contains originally from 3 per cent. to 12 per cent. of silver; after refining it is 994.5 fine. Australian gold is more or less brittle and the process is valuable for its toughening effects, as well as for its applicability to alloys containing but a small proportion of silver.

Platinum. Platinum is a lustrous, greyish-white, malleable, ductile metal, which is neither attacked by air nor acted upon by acids (except *aqua regia*). It therefore has claims to be included as a noble metal, and as its market value (about £7 15s. per oz.) is higher than that of gold, it is also a precious metal. At a red heat it may be welded, but cannot be melted by a temperature less than that of the oxyhydrogen flame. It is oxidised by fused caustic alkalies, and is also attacked at high temperature by cyanides. Platinum and iridium were not known in ancient times. Platinum is extensively used in high-class jewellery. Gold and other platinum alloys are used in mechanical dentistry.



REFINING AND ASSAYING APPARATUS

1. Amalgam filtering bag **2.** American amalgam retort **3.** Amalgam retort with condenser **4.** Refinery cupel **5.** Iron parting vessel **6.** Bucking plate **7.** Scorifier **8.** Assayer's cupel **9.** Mint assay cupels. **10.** Mint assay furnace **11.** Preparation of gold-silver button for parting. **12.** Assay parting flasks

Platinum ore contains what are known as the platinum metals—ruthenium, osmium, rhodium, iridium, palladium and platinum—in the metallic state. The most important sources are the western slopes of the Urals and the Altai Mountains. It is also found in alluvial deposits and sands, chiefly in Brazil, Borneo, Fraser River (B.C.), California, and Australia. It consists of from 60 per cent. to 80 per cent. of platinum. Osmiridium, a 30 per cent. to 40 per cent. osmium alloy, which is frequently found with it, is referred to below.

Platinum is separated from osmiridium by digestion with *aqua regia*, and from this solution it is precipitated by adding sal ammoniac. The precipitate is heated, treated with sal ammoniac to remove palladium and rhodium, and the resulting precipitate converted, by heating, into spongy platinum.

Osmiridium, frequently present in Californian and Canadian gold, is usually not detected until after parting, when it is seen in bar gold as specks or clots distributed through the metal. It is removed by re-fusing the gold, when it settles and forms what is known as a "bottom," which is cut off and repeatedly re-melted with silver. The bottoms are cut off each time, gold being replaced by the silver. It is finally separated by parting with *aqua regia*, when it is obtained as a black powder, which is sold for fountain-pen points at from 8s. to 20s. per oz.

Assaying. The assay of the ores and bullion of gold is conducted in the dry way, but silver bullion is also assayed in the wet way. The same dry methods apply to gold and to silver ores, since the metals are very rarely found separate. The principle of the assay is very simple, but its details vary greatly with the nature of the ores.

In the wet, or volumetric, process for silver assay the alloy is dissolved in nitric acid, and the silver estimated by the amount of a standard solution of common salt required completely to precipitate the silver nitrate as chloride.

Assaying weights are a law unto themselves. No scientific work is now done with the cumbrous English system of weights, but the custom still survives of expressing assay results in troy ounces per long English ton of 2,240 lb. avoirdupois, or short American ton of 2,000 lb. The metric system is rendered available by using a special weight called an "assay-ton" (A.T.) which bears to the ton the same proportion as the milligramme does to the ounce troy, so that each milligramme found in a sample represents 1 oz. per ton of ore. For the long ton the A.T. equals 32,666 milligrammes.

Sampling. The value of the sample of ore, or other material taken for assay, must approach as nearly as possible the true average value of the whole of the mine or material reported on. However great the accuracy of the assay, the result may be entirely negatived by careless or false sampling.

Sampling gold ores is a particularly delicate matter. In a finely-powdered ore containing 5 dwt. to the ton (a frequent proportion) a 1 milligramme partiticle of gold, about equal to the size of a full-stop, would possibly be accompanied by 160,000 similar sized particles of other substances. To get a correct sample of reasonable size of such a powder as this it is necessary to powder the ore more finely.

A true average sample is obtained in practice by automatic means. Sampling machines act either on the principle of continuously diverting a portion of a falling stream of broken ore or by diverting the entire ore stream at regular intervals.

By this means a ton sample of ore, broken to the size of coffee-beans, will be reduced to about 20 lb., and is then ready for further treatment in the assayer's office. There it is reduced in an iron mortar and a bucking-plate [6] till it will pass through a sieve with 80 meshes to the inch. Then it is well mixed and spread in a heap, which is carefully divided into quarters, one quarter being taken and again quartered until a sample of the required weight is obtained. If "metallics"—that is, pieces of gold of appreciable size—occur in the sample, they must be concentrated in a small portion by sifting, and assayed separately.

Bullion is sampled by dipping from the melt, by drilling holes in ingots and taking the turnings, or by removing pieces from opposite ends of the ingots.

Crucible and Scorification Assays. Fusion of the ore sample in the clay crucible with from once to twice its weight of a flux containing, typically, litharge, sodium bicarbonate, borax, and flour is adopted for ores of low gold value and for certain silver ores. The mixture is heated in a muffle or crucible-furnace until the charge is perfectly liquid, when it is poured into a mould. The slag containing the impurities is removed from the resulting lead button in which the silver and gold are concentrated, and the button is cupelled.

Scorification—that is, the conversion of silica and other gangue constituents into scoria—differs from cupellation only in the fact that the litharge produced is not absorbed by the vessel in which the operation is conducted, but forms a glassy slag. The scorifier [7] is a shallow dish of burned clay in which the ore sample, mixed with granulated lead and a little borax, is heated in a closed muffle furnace. When the lead is oxidised it dissolves the non-metallic and oxidisable constituents, flowing to the side of the scorifier as a slag, while the gold and silver alloy with a part of the lead which remains in metallic state. A glassy, brittle slag is obtained, which separates cleanly from the lead button, leaving it ready for cupellation.

Bullion Assay. If the composition of the alloy is entirely unknown, a preliminary assay is made to ascertain approximately the proportion of gold and silver, since (1) upon them depends the amount of lead used in cupellation, and (2) the final "parting" demands a definite ratio of silver with gold. Experienced assayers determine these quantities from the colour of a cupelled sample bead or of a streak upon the touchstone (Lydian stone, a silicified wood). The sample taken is flattened, adjusted to an exact weight by filing, and then weighed with great accuracy on a very delicate assay balance. It is then wrapped in the required amount of lead foil (eight times for standard gold), with silver equal to twice the weight of gold present. This proportion was first used in 1627, and was reverted to in 1905 by the Royal Mint after 50 years' disuse.

Cupellation and Parting. The principles of cupellation have already been explained. The cupel [8] used in ore assays is about 1 in. in diameter by ⅞ in. high. At the Mint a special form [9] is used, so that 72 assays may be cupelled at one time. Eighteen square bone-ash blocks—for example, with four cupel hollows—are used, fitting into a special muffle furnace [10] with a floor space of 6 in. by 12 in.

At the completion of cupellation, when the alloy bead is uncovered a sudden brightening of the bead is noticed at the moment of solidification, called "flashing" (due to the release of the latent heat of fusing). This is useful not only as a help in finding a minute bead, but also because it affords a means of ascertaining whether iridium, osmium, rhodium, or ruthenium are present, since these troublesome metals entirely prevent the phenomenon. In the case of pure silver this is the last of the operations, and the button can be directly weighed.

At the Mint the button [11A] of silver and gold is flattened by hammering [11B], annealed, and passed through laminating rolls until it is the thickness of a visiting card [11C]. It is again annealed, and rolled into a spiral [11D] called a "cornet." These are matters of some skill, for small particles may easily be lost by cracks or roughness of the cornets. The cornets are first boiled with pure strong nitric acid [S.G. = 1·2] in glass parting vessels [12]. At the Mint there are used platinum trays, on each of which 144 platinum cups containing cornets are placed, the whole being lowered into a platinum boiling vessel containing the acid at 90° C. The cornets are next washed with distilled water, and again boiled with stronger acid, repeatedly washed, dried, annealed, and carefully weighed.

Check assays are always made on pure gold to supply the correction necessary for the losses by volatilisation, cupellation, and acid solution. The gold finally obtained contains from 0·05 to 0·1 per cent. of silver. Mint weighings are now reported correct within 0·05 in 1,000.

Coinage. At an early stage in the history of civilisation it became necessary to have a definite medium of exchange. Metals, from their durability and portability, were very early in use, and gold and silver came naturally to be chosen from their intrinsic value. Reasons for the choice of gold, which partly apply to silver, are that it is too widespread to be liable to "cornering," as precious stones might be; that it is unalterable by time or ordinary chemical agents; that, wherever found, it is the same substance (unlike stones, which have faults not easily detected); that its value is the same whatever the size of particular pieces (the carat of diamond increases in value with the size of the stone); and, finally, though soft, it is readily made hard-wearing. Primitive payments were by weight, and this custom survives in our "pound," which was first a pound avoirdupois of sterling silver, while the penny was the weight in copper which we call a pennyweight.

Coinage has always been a regal privilege and mints date from the Anglo-Saxon period. In former times coining was carried out by contract with the Master of the Mint, but the head of the department on Tower Hill is now the Chancellor of the Exchequer, a deputy master being the permanent official.

Branch mints are established at Sydney, Melbourne, Perth, Calcutta, Bombay, and Ottawa, to supply their respective countries. Great Britain and the rest of the Colonies are supplied from the English Mint. The coins now struck are:

GOLD: £5, £2, £1, 10s.

SILVER: 5s., 2s. 6d., 2s., 1s., 6d., 3d.: and the Maundy money, 4d., 2d., 1d.

BRONZE: 1d., $\frac{1}{2}$d., $\frac{1}{4}$d.

The gold coins are $\frac{11}{12}$ pure gold and $\frac{1}{12}$ alloy by statute, and have been so uninterruptedly since the reign of Charles II. James I. debased the gold coinage to $\frac{8}{12}$ pure gold for revenue purposes. The silver is $\frac{37}{40}$ fine and $\frac{3}{40}$ alloy. The bronze is a mixed metal of copper, tin, and zinc.

"Trial" and "Remedy." When coins were made by contract it was necessary to ascertain periodically that the contract conditions were kept. This was called the "trial of the pyx," and it is still maintained with but little change. Finished coins are delivered in "journey weights," the supposed daily manufacture when coining was a hand process —15 lb. troy of gold (701 sovereigns), and 60 lb. troy of silver. From each of these deliveries one coin is taken and deposited in the "pyx," or chest, from which the annual trial derives its name. It is conducted in the presence of the King's Remembrancer by a jury of freemen of the Goldsmiths' Company, the coins being assayed against pieces cut from standard trial plates.

Variation in weight and constitution of coins from the standard fixed by law is permitted on account of the impossibility at present of ensuring an exact admixture of metals. It is called the "remedy," and is permitted to the extent of 2 and 1·6 parts per 1,000 for gold, and 4 and 4·17 for silver for fineness and weight respectively. Since a variation of $\frac{1}{10}$ of 1 part per 1,000 in the case of gold means a gain or loss of about £100 in a million sterling—its importance will be realised. In gold coins, however, a greater deficit, or excess, of from 0·3 to 0·4 per 1,000 is rarely met with. The legal standard is 916·6 parts per 1,000. The limit of weight variation for bronze coins is 20 parts per 1,000.

Light Coins. In the 1903 report of the Deputy Master of the Mint, Dr. Rose, the Mint chemist, stated that the average circulation life of the sovereign is 27 years, and of the half-sovereign 17 years. The coin has then lost by wear so much weight and fineness that it is legally uncurrent. Since the nominal and real values of gold coins are the same, this represents a considerable loss to the holders. In 1873 it was estimated that the loss on light coins in circulation from deficiency in gold amounted to about £650,000. The withdrawal of light gold coinage has been effected at intervals by raising the ordinary Mint purchasing price for light gold from £3 17s. 6½d., to the full statute Mint value of £3 17s. 10½d. per oz. Since the passing of the 1891 Coinage Act nearly £50,000,000 of light gold coins have been withdrawn by exchange at face value. In the case of silver these losses are covered by "seignorage," the difference between the real and nominal values of the coins. The yearly silver loss average for the decade 1896-1905, was over £35,000.

Coining Operations. In the early days of hand coining, cast bars of metal were hammered down to the required thickness, and the coins were cut therefrom with shears, the device being impressed by means of a hammer blow on a die. Now, however, the greatest care is taken, not only in the production of pure and accurate discs of the metals, but in the fineness of the alloy of base and precious metals used.

The Mint assay, melting and toughening operations for gold and silver have been described. The first operation now to be considered is the rolling of the cast bars into strips or "fillets." The manufacturing details for gold, silver and bronze coins are not materially different, and the sovereign will be taken as the type. The bar of gold, $\frac{1}{8}$ in. thick, is reduced by successive rollings (with frequent annealings to counteract the hardening effect) to the thickness of a sovereign. The accuracy of the thickness is tested by means of a gauge plate consisting of two steel bars set at a small angle graduated to $\frac{1}{1000}$ of an inch. For half-sovereigns a variation of $\frac{1}{1000}$ of an inch would more than account for the "remedy" allowed. The fillets are next tested by a "tryer," who cuts from them trial blanks, and by weighing on a delicate balance, classifies the fillets according to their weights.

Blanks for coins are punched in double rows from the fillets by cutting machines acting on the principle of the ordinary paper-punch. Bronze coins are cut five at a stroke. Slightly larger cutters are used for those fillets which have been classified as light, and vice versâ. The cut fillets, now known as *scissel*, equal from 25 to 30 per cent. of the original metal and are re-melted. So far it has not been found practicable to cut blanks from rods of metal, though such a method would represent a considerable economy.

In some mints the blank is adjusted to the required weight, but in London the finished coin alone is weighed, and the blanks are next thickened at the edge by rolling for the protection of the impression on the coin.

Coining and Automatic Weighing. The actual coining operation consists of placing the blank between two engraved dies in a press, the upper die being brought down upon it with considerable force. A collar surrounds the dies during the stamping to keep the blank in position, and, by means of cutting edges inside, to produce the milled edge. The coin is then driven down a delivery shoot by the succeeding blank. Ninety coins a minute are produced.

The concluding operation is the automatic weighing of each coin by a set of wonderful machines which infallibly distinguish between "light," "heavy," and "good" coins. The coins are fed in through a hopper, and received singly on the plate of a balance beam, one arm of which is weighted according to the coin tested. Rods raised by cams then release both ends of the beam and, if the coin is "light," the plate-end of the beam rises; if it is "heavy," the weighted end rises; if "good" the beam remains practically horizontal. These movements of the beam govern the action of levers that determine into which of three orifices a delivery shoot, free to move by being hung on pivots, shall deliver the tested coin. The mouth of the shoot is directly in front of the balance-plate, the coin being driven into it by the coin next behind it.

Precious Stones. The beauty and durability of form and colour of precious stones, and wonder at their physical properties, have always caused them to rank with the highest objects of human desire since their discovery in the East thousands of years ago. They are the centre of a great volume of romance and tragedy, and have induced the worst of human passions and crimes as well as the highest artistic expression. Mythology and history are so intermingled that it is impossible here to deal historically with them. In many cases identity itself has been lost. The famous Great Mogul has not been identified since 1739. It is said that the

"Orloff," the diamond set in the Imperial Russian sceptre, is the Great Mogul re-cut, or even that the Koh-i-noor, the diamond presented to Queen Victoria, is a piece cleaved off it in re-cutting.

Definition. Precious stones are not easy to define, for their preciousness is in part dependent upon caprice, time and place. Some writers make three classes—"precious," "semi-precious," and "common"; but this is not a stable classification. For practical purposes precious stones may be taken to be those mineral stones (and an animal product, the pearl) which possess beauty, durability, and rarity, qualities which may be described respectively as necessary, important, and desirable.

Formation and Location. Most of the minerals included under our definition are crystalline. Wherever crystals are found in Nature they must be the results of solidification from solution or fusion, and it is generally agreed that the hard gemstones have crystallised from fusion under pressures compared with which the mightiest forces man can control are negligible. For theoretical considerations of this crystallisation process, reference should be made to the course on GEOLOGY.

Precious stones are frequently and commonly found in association with the precious metals, but they are by no means confined to special localities. They are, however, most abundant in India, Burma, Ceylon, South Africa, Australia, Borneo, Siberia, and some of the Western American States. The most valuable stones are found in the older geological rocks—granite, gneiss, porphyry, mica schist, and limestone, embedded in or protruding from their bed, which, in this case, is the "primitive" bed of the geologists. Many are found in "derivative" deposits—alluvial gravels and sands—having been washed from their beds by rains and rivers.

Optical Properties. Gem stones are most conveniently investigated by means of their optical properties. The surface lustre of stones may be metallic, adamantine (for instance, diamond), resinous (garnet), vitreous (emerald), waxy (turquoise), pearly (moonstone), or silky (crocidolite). In most stones it is splendent, reflecting a sharp image, but the turquoise and one or two others are somewhat dull. To light, stones may be transparent (diamond), translucent (opal), opalescent (moonstone), chatoyant (cat's-eye), or opaque (agate). Stones of the "first water" are those of the highest degree of transparency, with no trace of colour.

Refraction [see PHYSICS] varies with the species greatly, and affords important evidence of identity. The diamond, spinel, and garnet, belonging to the cubic system of crystals, are singly-refracting. Most precious stones doubly refract, and have accordingly two refractive indices. These vary somewhat in the same stone, but the following abridged list of indices, calculated with sodium light and with air as unity, is fairly representative:

Diamond	2·417	Tourmaline	1·642
Zircon	1·950	Flint glass	1·619
Precious garnet	1·810	Beryl	1·575
Ruby	1·779	Rock crystal	1·549
Chrysoberyl	1·748	Crown glass	1·524
Peridot	1·659	Water	1·336

All doubly-refracting crystals, in virtue of this property, also polarise light transmitted through them [see Light in the course PHYSICS]. Those which also show that play of prismatic hues called *fire* (most evident in the singly-refracting diamond) do so because they also slightly disperse the colour rays composing white light. In this case the two images produced by the double refraction are of different colours, and the crystal is said to be *dichroic* or *pleochroic*. In the tourmaline and in iolite (a rare Ceylon stone) this dichroism is very conspicuous, but with most stones a dichroiscope is needed to discern it. The dichroiscope consists essentially of a Nicol's prism (Iceland spar), by which the light which is transmitted through a crystal is analysed, and its polarisation and dispersion rendered evident.

Mechanical Properties. One of the oldest methods of identifying precious stones is by testing their hardness; but many valuable stones have been destroyed through a confusion between hardness and brittleness. The hardness of minerals is measured by an arbitrary scale devised by Mohs, the degrees being the respective hardness of the following, in order from 10 to 1: diamond, sapphire, topaz, quartz, felspar, apatite, or glass, fluorspar, calcite, gypsum, and talc. Fragments of these minerals are used to determine, by scratching, the hardness of a stone. A hard steel knife is about 6 degrees. The values of the degrees vary greatly. For instance, the difference between the degrees 10 and 9 is much greater than between 9 and 8.

The specific gravity of precious stones varies very considerably, and its determination is the most general method of discrimination. It is referred to below in this connection. The heaviest stone is the zircon, the density of which varies, according to the colour variety, from 3·98 to 4·75. The lightest is perhaps the opal, 2·20.

Colours of Stones. Similar species of stones, practically identical in composition, present great varieties in colour. These variations are shown in tables given below for identification purposes. The colouring matter is generally one or more metallic oxides, frequently iron oxide, when the colour is said to vary with the number of molecules of oxygen in the oxide. But the whole matter is obscure, for the proportion of the constituents which determines the colour of a stone, and consequently its value, is often too small for its nature to be revealed by chemical analysis.

The colour of stones can be, and is frequently for market purposes, changed by heating. The corundums can be strongly heated with safety, pale blue and yellow stones becoming colourless. Inferior purple oriental amethysts are changed by heating to a beautiful pink or rose colour. Most of the coloured zircons lose or change their hue by heating; some become quite colourless, others change from brown or red to a dull green. Cloudy spots in rubies or jargoons may sometimes be removed by heating. Some stones are porous—such as agates and turquoises—and dyeing them is carried on as a regular industry. They contain microscopic cavities, which add to their brilliancy by internal reflection. The agate is blued by steeping it first in a solution of yellow prussiate of potash and then in a ferric salt, whereby a precipitate of Prussian blue is obtained within the stone.

Imitation Stones. "Paste" stones are usually made of *strass*, a fused mixture of a dense fusible glass with a large proportion of oxide of lead, some calcined potash, and a little borax and arsenious acid. They are coloured with metallic oxides. The product is a brilliant refracting and dispersing glass of a specific gravity nearly equal to that of the diamond. For an amethyst imitation, manganese and cobalt oxides may be used; for emerald, glass of antimony and copper carbonate; ruby, manganese dioxide; topaz, glass of antimony and purple of Cassius.

The test which practically all of them fail to pass is the file; some can even be scratched with glass

itself. Further, they show no dichroism (being non-crystalline), are heavier than the stones they represent, and contain specks and air bubbles visible with a hand-magnifier.

Doublets and triplets are false stones in which a valueless pale or colourless stone is given an appearance of a fine deep colour by backing it with a piece of deeply coloured glass or strass. Foiling is a legitimate means of increasing the beauty of a fine but pale stone; but in a doublet only the upper part, and in a triplet the upper and lower parts, are genuine stones, the cemented joint being in either case at the girdle of the stone, which is generally covered by the setting. The doublet is detected by scratching the base, while if the triplet is immersed in water its three layers become visible.

Imitation pearls are small globes of opalescent glass, which are coated with essence d'Orient, a preparation of the scales of a tiny fish—the bleak. An iridescent effect is produced by heating them under pressure with hydrochloric acid.

Artificial Stones. Artificial stones are products more creditable and more successful than the imitation. Rubies and sapphires of considerable size, and identical in form, density, and hardness with the natural corundums, have been largely made by crystallisation from fused alumina, with traces of chromium or other colouring oxides. Exact details of the process are not known. They are distinguished only by microscopic examination, when it is seen that the cavities, which in the natural stone are angular, are in the artificial spherical. "Reconstructed" rubies and sapphires are built up from real small stones by fusion in the electric arc. Red spinel has also been successfully produced from fused alumina and magnesia dissolved in boracic acid. A lime spinel, which has been sold for blue sapphire, is made by fusing alumina and lime, tinctured with cobalt. Crystalline silica compounds are produced by interaction of their components in the gaseous state. The most famous experiments in this connection are those of the late M. Henri Moissan, who crystallised carbon under great pressure into minute diamonds, the largest of which, however, has not a greater diameter than one-fiftieth of an inch. Molten iron dissolves carbon, and if this solution be suddenly cooled a hard, rigid shell is formed, within which the carbon is thrown out of solution as the still liquid part cools. At the point of solidification, iron expands, and under the enormous internal pressure thus produced the carbon assumes the crystalline form.

Identification. The need for means of determining the genuineness of precious stones coexisted with the discovery of glass. Besides the expert knowledge which can be acquired only by experience in handling stones, there are certain facts which supply most of the information necessary for identification. Colour and hardness may not be sufficient. Among the "colourless" stones, for instance, the jargoon, tourmaline, and aquamarine all have approximately the same degree of hardness. Their specific gravities determine their identities. Chroism and the refractive index are the final physical tests. The Röntgen rays have been used. Tests for mechanical properties are best made on unmounted stones. Faceted stones, however, may be scratched on the edge of the back corner of one of the bottom facets. Great caution is needed, for stones which cannot be scratched may be chipped or broken. The hardness scale should be gone through upwards. Glass imitations may be detected by the fact that they do not scratch glass.

The ordinary methods of finding specific gravity are given in the course on PHYSICS. Those constantly handling stones use a more convenient method. A set of heavy liquids (usually six) of known densities, increasing from about 2·65 to 4·5 (stones vary from 2·4 to 4·75) is used, and the specific gravity of a stone is sufficiently approximated by noting its behaviour when immersed successively in the liquids. That liquid in which it floats is heavier, and that in which it sinks lighter, than the stone, and it is obvious that as the liquid approximates its density it will rise or sink more slowly. The liquids used are: the poisonous double nitrate of thallium and silver (fused at 70° C. = 4·5; solution at 150° C. = 3·5), cadmium boro-tungstate solution (= 3·3), methylene iodide saturated with iodoform (= 3·6), the same pure (= 3·3), and diluted with toluene or benzene (= from 3·0 to 2·65).

Porous stones, such as turquoise and agate, must not be immersed in these liquids.

The tables following present the characteristics of stones in the order of their importance for identification:

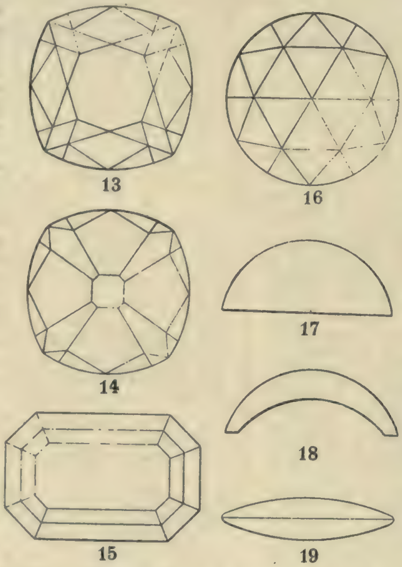
Colour.	Name.	S.G.	Hardness.	Chroism.
COLOURLESS	Jargoon (zircon) ..	4·68–4·75	7½	M
	Sapphire (corundum)	3·97–4·05	9	M
	Diamond	3·52–3·53	10	M
	Topaz (Brazilian) ..	3·0–3·3	8	M
	Tourmaline (achroite)	3·0	7–7½	M
	Rock-crystal (quartz)	2·65	7	M
BLUE	Sapphire (corundum) ..	3·97–4·05	9	Strongly D
	Spinel	3·6–3·7	8	M
	Topaz (Brazilian) ..	3·5–3·4	8	Distinctly D
	Bone turquoise (odontolite)	3·0–3·5	5	—
	Fluorspar	3·0–3·25	4	Strongly D
	Tourmaline (indicolite)	3·0–3·2	7½	Strongly D
	Turquoise	2·75	6	—
	Aquamarine (beryl) ..	2·69–2·7	7½–8	Distinctly D
RED AND PINK	Jargoon and hyacinth	4·65–4·70	7½	Very faintly D
	Ruby, or pink sapphire	3·97–4·05	9	Strongly D
	Garnet (pyrope) ..	3·70–3·80	7–7½	M
	Spinel (balas ruby) ..	3·60–3·63	8	M
	Topaz (Brazilian) ..	3·54–3·56	8	Strongly D
	Tourmaline	3·02–3·1	7–7½	Strongly D
PURPLE	Garnet (almandine)	4·1–4·3	7½	M
	Sapphire (oriental amethyst)	3·97–4·05	9	Strongly D
	Amethyst	2·65	7	Distinctly D
YELLOW	Jargoon (zircon) ..	4·3–4·63	7½	Faintly D
	Sapphire (oriental topaz)	3·97–4·05	9	Faintly D
	Chrysoberyl	3·65–3·78	8½	Distinctly D
	Garnet (cinnamon stone)	3·55–3·65	7–7½	M
	Topaz (Brazilian) ..	3·5–3·56	8	Distinctly D
	Chrysolite (olivine) ..	3·3–3·5	6½	Faintly D
	Scotch topaz (citrine, quartz)	2·65	7	Faintly D
GREEN	Jargoon (zircon) ..	3·98–4·1	7½	Faintly D
	Sapphire	3·97–4·05	9	Strongly D
	Demantoid (Bobrovka garnet)	3·83–3·85	6	M
	Alexandrite (chrysoberyl)	3·68–3·78	8½	Strongly D
	Peridot (olivine) ..	3·3–3·5	6½–7	Faintly D
	Tourmaline	3·1	7–7½	Strongly D
	Emerald	2·70–2·71	7½–8	Strongly D
	Aquamarine	2·69–2·7	7½–8	Faintly D

The third column gives specific gravities, and in the fifth "M" indicates monochroism, and "D," dichroism.

Cutting and Polishing. The rough treatment to which most precious stones are subjected

in nature, and the general occurrence of flaws, as well as the development of their optical beauties necessitate cutting and polishing. Stones are either cut in facets or *en cabochon*. Transparent stones—with the exception of the garnet—are faceted to permit the full display of their refraction, chroism, and dispersion upon which their beauty largely depends. The proportions vary in accordance with the optical constants for each species of stone. The principal forms of cutting are brilliant [**13**], step or trap [**15**], and rose [**16**]. The first is reserved for the real diamond, so that the term is synonymous with diamond. The face is called the *crown* [**13**] and the back the *pavilion* or *base* [**14**]; there are usually 33 facets in the former (the principal being the table), and 25 in the latter (the culet, or collet, and the pavilion are the principal). The step-cut is used for emeralds and other coloured stones. The rose-cut is the oldest form. The base may be flat or similar to the upper part.

Translucent and opaque stones are cut *en cabochon* [**17**]. The garnet is cut somewhat hollowed behind [**18**], for foiling; while for opals, the tallow topped cabochon [**19**] is used. These forms are almost essential to some stones, and they are convenient for stones set in large objects, like vases, which are handled.



13 14 15 16 17 18 19

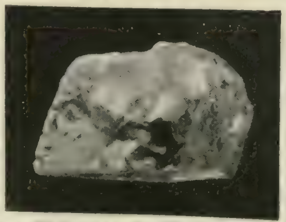
FORMS OF CUT STONES

13. Crown of brilliant **14.** Pavilion of brilliant **15.** Step-cut stone **16.** Rose-cut stone **17.** Cabochon-cut stone **18.** Hollow cabochon-cut stone **19.** Tallow-topped cabochon-cut stone

In cutting, diamonds are first reduced to their required form, to remove defects and to rough out the facets, by splitting down their planes of cleavage. This is effected by a hammer blow on a knife placed in a slot cut by diamonds. They are faceted by rubbing two together (*bru'ing*), fixed on sticks with graver's cement, the dust being saved for cutting. Polishing is done on high-speed cast-iron or other metal wheels, with diamond dust (*boart*) and olive oil, one facet at a time, the process being long.

Softer stones are more easily cut. Soft stones are cut on a flat emery grinding lap. Diamond-boart or corundum, on a metal lap, is used for harder stones. Final polishes can be given on buffs, with fine emery, tripolite, rottenstone, putty powder, etc.

It will be convenient to classify the various stones according to their chemical composition—the element (diamond), the compounds—oxides silicates, aluminates, phosphates—and the organic products.



20. CULLINAN DIAMOND
One-fourth scale

Diamond. Owing to its pre eminent qualities, and partly also to its comparative abundance, the diamond is the most important of the gems, though not the most costly, and it has been computed that 90 per cent. of the stones on the market are diamonds. It is the hardest, and has the highest refractive (2·419) and dispersive powers, to which it owes its wonderful play of colours and fire. The most important sources are South Africa, Borneo, Brazil, New South Wales, Bahia, and India. The Cape industry originated with the historic discovery in 1867, by a Dutch farmer's child, of a rough pebble, which was sent to the Paris Exhibition of that year, and sold for £500. Thus were started the river diggings, which still produce the finest stones. The Kimberley workings originated in a somewhat similar find, in the mud walls of a Du Toit's Pan farmhouse. From that time to the end of 1904 it has been estimated that the value of the South African diamond exports has been not less than £85,000,000, one year (1903) alone equalling about $5\frac{1}{2}$ millions sterling.

The "yellow earth" and "blue ground" diamond-bearing material is a soft, soapy rock, a mixture of erupted and metamorphosed sedimentary rocks. In the Kimberley mines it occurs in vertical funnels about 200 yards in diameter, and of unknown depth. It is "weathered," and a concentrate of pebbles obtained by crushing, washing, and screening. This contains other stones—garnets, zircons, etc.—but owing to the fact that diamonds are more easily oiled than wetted, while the great majority of the minerals have the reverse property, the diamonds are readily separated by passing the concentrate over rocking cast-iron plates covered with a thick layer of grease. Oil is used for the same purpose.

Much romance is connected with the famous diamonds of the world, which cannot be gone into here. The largest white diamond is the "Cullinan" [**20**], found in the Premier Mine, Pretoria, in January, 1905. Its weight is 3,032 carats (nearly $1\frac{3}{4}$ lb. troy), and its largest dimensions are about $4\frac{1}{4}$ in. by $3\frac{1}{4}$ in. It is a piece cleaved off a crystal four times its size. It is of exceptional purity, and has been valued at £500,000. It would probably be impossible to find a purchaser if it were cut as one stone. Before its discovery, the "Excelsior," weighing $971\frac{3}{4}$ carats, was the largest.

Diamonds and other stones are sold by the carat, a weight which varies somewhat, but equals, in England, 3·168 grains, or 0·205 gramme. It is divided into four diamond grains. Commercially, the finest diamonds are bluish-white, coming from the Jagersfontein mines. "Fancy" stones — red, green, blue, pink, and violet (their value is in this order) — are extremely rare, and a 1 carat red diamond has been sold for £800. "Gem stones" is a trade term confined to the finest stones. Brilliants are stones cut with the full number of facets

and are mounted in open settings. The small stones generally known as diamonds are pieces cleaved off brilliants. They have only the crown facets and no base and are used in closed settings.

Rubies, Sapphires, and Other Oxides. The oxides include the corundums, quartz, chalcedony, and opal. Corundum (alumina, Al_2O_3) is the chief constituent of the stones next to the diamond in hardness, stones varying optically and in colour as greatly as the ruby, sapphire, oriental amethyst, and oriental topaz, yet differing chemically only in respect to small proportions of metallic oxides, which do not, however, necessarily determine colour.

Rubies and emeralds share the distinction of being the most costly stones. Rubies of the perfect pigeon-blood colour are extremely rare, and practically come only from Burma, where they are found in transparent crystals in limestone. The ruby-earth is called *byon*, and is separated in rotary pans and pulsators. Rubies increase greatly in value with their size. A faultless 5-carat stone would probably sell for £3,000, while a similar diamond might not fetch more than £350. A fine 38-carat ruby was sold for £20,000. Chemical and artificial rubies and emeralds have, however, greatly affected the value of all but the finest stones.

The finest sapphires are a velvety, corn-flower blue, and come from Siam. They are very rare, but large sapphires are much less infrequent than large rubies, and they are worth considerably less than diamonds. Though so hard, the sapphire was occasionally engraved in Roman times. It has always been a stone of great sacred interest.

The varieties of amethyst, topaz, and emerald, known as *oriental* are violet, yellow, and green sapphires respectively.

Corundums occasionally show an opalescent six-ray star, due to intersecting striations. These "star-stones" are cut *en cabochon* [17].

Quartz (silica, SiO_2) includes a large number of stones which, chiefly because of their abundance, can hardly be termed precious, except the amethyst, The purest form is rock crystal. The amethyst owes much of its beauty to its peculiar rippled structure, its dichroism, and its deep purple hue.

Other varities of quartz are chalcedony (known as *agate* and *onyx* when in different layers of different colours, and *chrysoprase* when green); cat's-eye, a vitreous stone with opalescence due to fibres of asbestos, from Ceylon; cairngorm, a smoky-yellow to brown Scotch stone; and jasper, an opaque red, green or yellow stone. The Scotch topaz is yellow quartz.

The *Precious Opal* is the only gem opal, and is distinguished by its wonderful play of the most brilliant colours, from a milky bed, red predominating. This is entirely due to the mechanical fact of striation. It is essentially silica, but differs from quartz in that it is non-crystalline, and contains combined water. Hungary and Queensland supply the finest noble opals. Fire opals come from Mexico.

Aluminates are represented by *spinel* (magnesium aluminate, $Al_2O_3.MgO$), and *chrysoberyl* (beryllium aluminate, $Al_2O_3.BeO$). Spinels are of all the colours of the spectrum, are important because of their hardness [8], but lack refraction, dispersion, and pleochroism. The balas ruby is a red spinel.

Chrysoberyl includes true cat's-eye (yellowish-green, with whitish chatoyancy), oriental chrysolite, and alexandrite (a Ceylon stone of leaf or olive-green, appearing red by lamplight).

Most of the precious stones are grouped under the somewhat indefinite heading "Silicates"—that is, these can be regarded as chemically derived from silicic acid.

Emerald and Zircon. The precious beryl is a silicate of beryllium and aluminium ($3BeO.Al_2O_3.6SiO_2$), and is represented by the *emerald*, the second most valuable stone, and the aquamarine. No stone, perhaps, is more unequal in value than the emerald. Stones of the deep, rich, velvety green, which is prized, are very rare indeed. Their beauty is probably due to a chromium salt. They came from Egypt in ancient times, but are now obtained only from the famous Muzo mines of Colombia. Emeralds are also found in the Urals and New South Wales.

The *Aquamarine* is a pale sea-green or blue variety, from Brazil, much less prized, often flawless, though of considerable size. An emperor of Brazil had one weighing 225 oz. troy, without flaw.

Common muddy crystals of beryl are often found of great weight. One from New Hampshire, U.S., weighed nearly 2½ tons.

Many varieties of zircon ($ZrSiO_4$) are lovely stones, particularly those of reddish and brownish tints, the true *hyacinth*, and the true *jacinth*. The colourless yellow and green stones are jargoons, which have almost the fire of the diamond, share with it a brilliant adamantine lustre, and exhibit many rich and delicate hues. The jargoon is the heaviest precious stone, and the density varies with the colour in a greater degree than in any other stone. Ceylon supplies the finest colourless zircons, which are frequently used as diamond substitutes. Hyacinths are found at Expailles, in Auvergne. These stones are not very valuable, 26s. a carat being a record price.

Garnet and Topaz. There are a large number of garnets, differing greatly in colour, density and hardness, but crystallographically similar (cubic system), and of the general chemical formula $3SiO_2.R_2O_3.3MO$. The more important are here noted.

The *Precious Garnet* ($3SiO_2.Al_2O_3.3FeO$) or Almandine (called carbuncle when cut *en cabochon* [18]), is purple violet to a reddish brown. *Cinnamon-stone* or Hessonite ($3SiO_2.Al_2O_3.3CaO$), incorrectly called hyacinth, is a Ceylon stone of a deep honey-yellow with a red tinge. *Pyrope*, or Bohemian garnet, is very variable in composition, but is essentially $3SiO_2.Al_2O_3.3FeO.MgO$. It is usually a deep blood-red, but is inferior in all respects to the ruby. Bohemia, New Mexico and South Africa are its sources. *The Bobrovka Garnet* or Demantoid (approximately $3SiO_2.Fe_2O_3.3\,CaO$), wrongly called olivine and Uralian emerald, is popular owing to the similarity in colour to the emerald. It has brilliancy and fire, but is somewhat soft. The true *Olivine* species includes the greenish-yellow chrysolite and the pistachio-green peridot, or evening emerald (containing SiO_2, MgO, and FeO), a soft stone, frequently engraved, coming from Egypt. What is usually called olivine by jewellers is the green garnet, the demantoid.

Topaz and Tourmaline. Pseudo-topazes have been mentioned above. The true stone is the Brazilian (probably $2Al_2O_3.SiO_2.SiF_2$ and combined water), a wine or amber-yellow, blue, or remarkably brilliant, colourless stone (Goutte d'Eau). The yellow stones become rose-pink on heating and are sold as "burnt topazes." The commercial value of the stone is small.

The *Tourmaline* is chemically the most complex of all the precious stones. It is a silicate with

bases of the oxides of iron, manganese, sodium, aluminium, and perhaps manganese, potassium and lithium and other metals. The species includes achroite (colourless), indicolite (blue), and rubellite (red). It has extraordinary polarising and dichroic properties, which give it exquisite and striking colour changes, according to the direction of the light transmitted in the facets. It has remarkable electric properties.

Turquoise, or callaite, is the only phosphate among the gems ($2Al_2O_3.P_2O_5.5H_2O$, with some CuO). It is not entirely opaque, and the best stones are a delicate sky-blue tinctured with green. It is not crystalline. Nishapur, Khorassan, is the chief source. Fossil turquoise (odontolite) is fossilised mastodon teeth coloured with iron phosphate.

Lapis-lazuli is a mixture of minerals in which rich blue complex silicates, Haüynite, the true ultramarine (the once costly pigment now replaced by a chemical equivalent), sodalite, etc., predominate in patches. It is coming more into use in modern artistic cost-ignoring jewellery.

Pearl and Coral. Of the organic products the pearl is the most valuable. It consists of lustrous regular concentric layers of the form of calcium carbonate known as *aragonite*, and is secreted by the mantle of the pearl-bearing oyster or mussel, *Margaritifera vulgaris*, of Ceylon, and *Margaritana margaritifera*, of Great Britain, being the best-known molluscs, respectively. It is due to the irritation of the mantle by a minute parasite or a grain of sand. A pearl weighing 1 carat standard quality may be worth £10, or £80 if of 4 carats. A Shah of Persia paid £55,000 for a pearl weighing nearly 170 carats. The largest is probably a *baroque* (that is, of irregular shape) pearl, weighing 455 carats, 2 in. long and 4½ in. in circumference. Pearls are found of all colours, black being the most esteemed.

Coral used in jewellery, white, pink and red, is the product of a single species of polype, *Corallium nobile*, found in the Mediterranean, the coasts of Provence, North Africa, and elsewhere. It is mainly calcium carbonate, with an unknown colouring matter.

Amber and Jet. Amber is an unchanged fossilised pine resin of the Tertiary period. It is found on the shores of the Baltic, Sicily, Norfolk, and Suffolk, and in Upper Burma. Its density is about 1·08 and hardness 2½. Sicilian amber is fluorescent in sunlight. *Jet* is a dense, homogeneous variety of coal. Whitby, Yorkshire, is the principal source.

Gold-work and Jewellery. From the remotest days personal ornaments have been prized, and where, in the beginnings of civilisation, the precious metals and stones attracted man's attention, the craft and art of precious-metal working and jewellery was begun. From the purity in which it occurs, gold was probably the first metal used by man. From the earliest times some artists have chosen to work in the precious metals. The Egyptians, the Etruscans, and the Grecians attained standards of artistic excellence which, it is said, have never been equalled in modern workmanship, and certainly have not been surpassed. Nearly all the methods of working now used—repoussé, enamelling, filigree, soldering, and many others—were practised in these early times and developed to the highest pitch.

Gold-working, like all arts, has progressed in cycles. There were long periods in which it seemed to become increasingly mechanical and a mere matter of workshop copying, which were followed by artistic revivals. Such were the Roman, Byzantine, the ecclesiastical of the eleventh century, the Renaissance and the Celtic periods. Modern gold-working is the sum of the many small improvements in form and method produced in all these periods. Essentially, it contains nothing new, for its best is after Nature, and therefore classic; but only in the sense that the classic furnishes models and suggestions for the expression of modern ideas. What is termed the "New Art" has been described, not without merited scorn, as "that corrupted compound of uneasy vermiformity, slickness, and imbecility—the art of the undying worm."

From the purely artistic point of view modern work has suffered much by the application of machinery; but, at the same time, there is much that is good in the better class machine-made work, and it has made it possible for good, simple work to be known and used by the people.

The important centres of modern jewellery production are Paris, Vienna, the Clerkenwell district of London, Birmingham, and New York. The revocation of the Edict of Nantes is probably responsible for the Clerkenwell trade, as most of the skilled artisans of the district appear to have had Huguenot ancestors. The Birmingham trade no doubt originated in the skill previously reached in fine steel-work.

Modern work consists either of pure metal-work (called "Plate" if not jewellery or coin), metal with decorative precious stones, or work of which precious stones are the feature. In the early part of the nineteenth century the last class was the most important, and but little artistic skill was displayed in the settings, but with the greatly lessened rarity of diamonds, resulting from the large South African supplies, stones have come to take a more subordinate place, and in much of the highest class of modern work there is an almost entire neglect of gems for their intrinsic value.

Materials and Alloys. Fine gold is too soft to stand any wear, and must be hardened by alloying. Alloys are denominated by the number of carats to the ounce of 24 carats which they contain, but they are made up by the ounce, dwt., and grain. In alloying most metals, definite proportions must be observed or liquation will occur, but copper and gold and silver and gold alloy in all proportions. Silver alone produces a greenish gold, while copper gives a red gold, and a mixture of the two as an alloying metal gives an alloy of colour somewhat similar to pure gold. It is, of course, an important factor in the choice of metal for any particular purpose. Red alloys are, naturally, cheaper than green.

The best metals for working and appearance are 22 carat and 20 carat. High class trade jewellery is 18 carat—that is, three-quarters pure. The public taste is for red gold, but the increase in copper which this necessitates produces an alloy which is somewhat hard and liable to crack in working unless great care has been taken in its preparation, and it is frequently annealed in the early stages of working it. Alloys with silver only are more ductile and much easier to work. For repoussé work gold is alloyed with silver down to 12 carats. The alloys used by jewellers are very many and vary greatly with their use. Some of the representative alloys for general purposes are tabulated below. Alloys under

10 carats fine are partly made up with "composition," a mixture of spelter and copper:

Gold—Carats.	Fine gold.	Fine silver.	Fine copper.
22	0·92	0·04	0·04
22 (coin)	0·917	—	0·083
18	0·75	0·125	0·125
16	0·6625	0·075	0·2625
15	0·625	0·125	0·25
15 (green)	0·625	0·375	—
15 (red)	0·625	0·025	0·35
15 (for settings)	0·625	0·225	0·15
12	0·5	0·154	0·346
10	0·416	0·204	0·384

The cost of alloys varies, of course, with the proportions contained in the alloying metal. It is said that a homogeneous alloy of platinum and gold cannot be obtained.

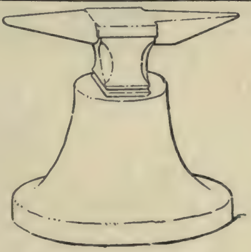
Jewellers' solders are low-grade gold and silver, copper alloys with spelter added, made up with scrap metal as required, by melting in a clay crucible. Gold solder may cost from 35s. to 55s. per oz.

from the bench and the floor, are sold to the refiners.

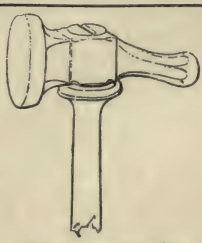
The following tools are those ordinarily required in gold working and jewellery: polishing, lapping, and gold-cutting lathes; the sparrow-hawk [22], or beck iron, is a bench anvil; nipper for cutting wire and sheet metal, and for piercing holes in sheet; joint-making tool for hinges; taper treblets, made of turned steel or hardened cast iron, for shaping finger rings and the edges of collars, lockets, and bracelets; a steel doming block [23], and a set of doming punches; micrometer gauge for measuring thin sheet; a drill stock, bow, or Archimedean; snarling irons for repoussé; broochers, burnishers; chasers and matting tools; set of files (needle, round, flat, three-cornered, and riffle); scorpers for carving and engraving; blowpipe; drawplate for wire-drawing; hammer [24] and mallet for repoussé, chasing, and relief work; pliers; screw-plate; bench and hand vices; flatting mill; polishing brushes and buffs.

Rolling and Wire Drawing. Sheet metal and wire are produced from the ingot by the

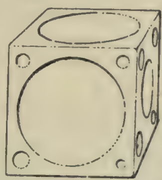
21. JEWELLERS' BENCH



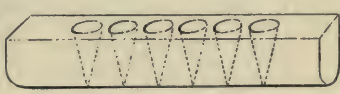
22. SPARROW HAWK



24. JEWELLER'S HAMMER



23. DOMING BLOCK



25. DRAW PLATE

23. DRAW-PLATE PUNCH

JEWELLERS' TOOLS

Fine gold is always sold at the following standard rates according to quantity: 1–5 oz., 86s.; 5–10 oz., 85s. 6d.; and 10–50 oz., 85s. 3d. Silver fluctuates according to bullion market rates. In December, 1906, it stood at 2s. 7d. per oz. A 22-carat alloy costs about 78s. per oz.; 18 carats, 64s.; 16 carats, 47s.; and so on. Silver alloys contain nickel and copper or German silver, and cost about 30s. 6d. per oz.

The Workshop and Tools. The jeweller's work-bench consists of a hard, semicircular beech board, shaped to take the body of the worker. The illustration [21] shows a five-place bench. A rest for filing or engraving is provided in the centre of each bow. A tanned skin is fastened underneath each worker's bow to catch filings of the precious metals and to hold tools. Tin trays are sometimes used, but they are liable to damage work which may be dropped into them. A grating is placed on the floor underneath the bench to catch stray filings which, with the daily sweepings

flatting mill [see page 5522]. The rolls are of polished cast steel and revolve in opposite directions. Multiple speed and power rolls are also used. Rolling hardens the metal, and it has to be frequently annealed by keeping it at a red heat in a muffle for a period increasing with its fineness. Gold can be reduced to nearly the thickness of tissue paper by a good pair of rolls. Rolls with characters and designs engraved on them are used for embossing, etc.

For coarse wire the ingot is rolled to the required gauge, annealed, and slit in rolls with regular cutting slots. The square strips produced are then passed through wire rolls having circular grooves.

A simpler method is drawing a rod of metal through holes in a steel drawplate diminishing in size. Gold is so exceedingly ductile that it is said 1 oz. can be drawn out into a wire 60,000 ft. (over 11 miles) long. The average length of best filigree wire obtained from 1 oz. is 4,500 ft. After the rolling and slitting above described, the wire is pointed,

rubbed with beeswax, or oiled, and pulled through the largest hole in the plate. The end is then attached to the draw tongs of a drawbench, and the wire drawn repeatedly until it is sufficiently reduced.

Small tubes, for brooch, locket, and other hinges, etc., are made similarly. A strip of metal about three times as broad as the tube diameter is hammered into gutter form along its length, the point tapered and inserted in the plate. A pointed burnisher is kept in the hollow of the gutter behind the plate to keep the tube true as the metal folds round during drawing.

A convenient form of drawplate [**25**] is made of soft steel, the size of the holes being adjustable. They can be closed with a round-faced hammer or opened with a steel puncher [**26**].

Melting and Casting. Alloys of gold and silver are melted in a *wind* or portable furnace lined with firebrick, in plumbago or clay crucibles. Three-ounce ingots are produced rapidly without a furnace by means of a combined crucible and ingot mould. The metal is melted with a blowpipe, and run into the mould by tilting the whole apparatus.

For casting very small work a mould of cuttle-fish bone is used. A clean and perfect piece of bone is cut into halves between which the pattern is placed, and an impression taken. The pieces are bound together with iron wire, and the metal, melted on charcoal, run in. Larger and rougher work is cast in moulding sand and loam packed in iron casting flasks round the pattern and dried thoroughly.

Piece moulding, for complicated and undercut work, is similar in principle. False cores are used so that the mould can be taken to pieces to remove the pattern and reformed for casting. The model is first made in wax or clay, and a cast taken in plater of Paris.

The waste-wax method permits greater finish. A model is made in casting wax, and then coated, at least 1 in. thick, by means of a camel-hair brush, with a paste of moulding sand, ground very fine, with water. An impression is taken in sand as usual, and the mould heated until all the wax is run out, leaving a hollow mould of fine sand. A sand core on an iron wire coated with flour paste is used for hollow castings.

Soldering. Solder is made as wanted from scrap metal. For ordinary work, silver cuttings and fine brass or spelter (2 to 1) are melted in a clay crucible, and cast. A hard enamel solder is made with fine silver and copper, 4 to 1. Solders become more fusible as the proportion of silver is decreased.

Gold solder may be made by adding 5 gr. of fine silver to every dwt. of the alloy which is being used for the work in hand, and melting on charcoal with borax.

Soldering is an exceedingly simple and satisfactory process if all the materials used are absolutely clean. Small panels of solder are cut out, dipped in borax, and held in position by means of the binding wire which holds the piece of work together. For silver work the solder will not enter the join if the edges are brought too close together; but in gold work the fitting cannot be too close.

All work must be boiled out after soldering, in pickle—a weak solution of hydrochloric acid.

Colouring and Gilding. The pale colour of gold which is inferior or contains too much silver can be enriched by "dry" or "wet" methods. In the first the surface silver is removed by dipping into a fused solution of saltpetre and the sulphates of zinc, iron, and aluminium in their water of crystallisation. It is not applicable to less than 18-carat gold. Gold from 9 to 15 carats can be darkened by heating. The wet methods are applicable to all golds. Hot solutions of hydrochloric acid, saltpetre, common salt, and, for higher qualities, alum, or of ammonium sulphide, are used.

New silver work which looks unpleasantly white and glaring can also be darkened—from a pale straw to purple—with a very hot ammonium sulphide solution.

The oldest and best method of gilding is by amalgamating the surface of the metal with a stiff gold amalgam, the mercury being driven off by heat. The surface is first prepared with mercury nitrate. However, this and such processes as painting on a nitric acid solution of mercury and gold chlorides, or burnishing on gold leaf, have been quite superseded by electroplating.

Finishing. The final processes by means of which tool marks are moved and a surface finish given are polishing and finishing. They require much skill and experience, because high-class work is easily spoiled if sharp edges are rounded, and relief lessened, or other delicate details coarsened. The work is first cleaned by pickling, and then rubbed carefully with water of Ayr stone to remove oxide film and tool-marks. Finer polishings are then given successively with charcoal and oil, rotten-stone and oil, and jewellers' rouge and water. The work is finally washed in hot soap and water, and dried in boxwood sawdust. Flat surfaces are often wet coloured between stoning and polishing.

Round surfaces and repoussé work are first stoned, as before, and then polished with circular rotating brushes, first with scratch brushes and stale beer, then with a brush charged with rotten-stone and oil. If a higher polish, called "bright finish" is required, a circular calico mop, charged with rouge, is used. Chains and surfaces requiring faceting are finished on the lapping lathe, which cuts away the surface on special parts leaving it bright.

Inlaying and Filigree. *Inlaying* is largely a matter of patience after the required designing skill is obtained. The design is engraved out of the metal with scorpers, the edges of the lines and spaces being undercut. Fine gold or silver wire, a little larger than the thickness of the engraved line, is then gently hammered in. The ground of spaces is roughened and sheet metal hammered in. [Niello inlaying is described on page 5529.]

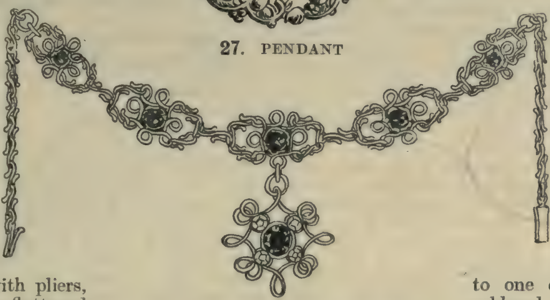
Damascening is a similar process applied to steel. In two cheaper methods the ground to be covered is roughened either with the scorper point and thin gold or silver hammered on, or by cross lines cut with a graving tool and gold leaf burnished on.

Filigree jewellery work is fashioned with fine threads and beads of gold and silver, curled, twisted, and plaited, and united at points of contact with gold or silver solder, where small grains of gold are also often placed. The Greeks and Etruscans had a wonderful knowledge of gold soldering, and some of their finest work is built up by soldering incredibly fine gold wire and minute grains of gold on to the surfaces of small objects. The secrets were entirely lost until some of them were revived some years ago by Cassini, who discovered in Venice descendants of the original workers. Eastern filigree work is particularly noted for its beauty. Modern work consists of buttons, brooches, crosses, earrings, etc., surrounded and broken up by bands of solid metal to give strength to the design. The wire for the purpose is made by drawing through minute holes drilled in rubies set in brass plates.

Articles of Jewellery. The application of the foregoing processes will best be indicated by the production details of a few specific articles.

Chains for all purposes, except, perhaps, necklaces, are generally machine-made. They are probably superior in design and execution to most of the hand-made, for chains obviously offer great facilities for mechanical repetition. For necklaces which are not of fine or Venetian chain, where stones are set in gold wire-work connected by chain links, the links are frequently hand-coiled. The wire — simple, double, twisted, or flattened—is coiled closely and regularly round a paper-covered mandrel (of the shape and size required for the links), and the mandrel is withdrawn by charring the covering paper. If the spiral then be sawn through lengthwise a set of links will be obtained, different varieties of which can be looped together to form the chain. If solid curb chains are made by hand, the links, formed as described, are made into curbs by sharp bending with pliers, and the whole chain is flattened with a mallet. For hollow chains gold is drawn through the plate round charcoal iron wire, which is removed when the chain is complete by boiling in dilute sulphuric acid.

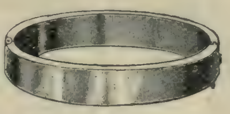
27. PENDANT



28. WIRE-WORK NECKLACE

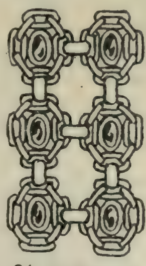
29. FLEXIBLE BRACELET LINKS

Necklaces are usually designed on a 4½-in. circle, pendants being arranged on radial lines of the semicircle. Good effects are obtained by twisting flattened single or twisted wire or filigree wire in knots and wreaths round the stones used, linking all together with chains and loops. Such a design is shown [28]. A design for a pendant in pierced and repoussé work for an all-silver necklace is given in 27.



30. HINGED BAND BRACELET

For gold work the two halves of pendants are shaped with a burnisher out of thin metal on a brass model set in graver's cement. The halves are strengthened with wire, soldered inside, and then soldered together. Ancient necklaces were made up of simple pendants burnished in this way on matrices engraved in brass.



31. FLEXIBLE BRACELET LINKS

Bracelets vary from 6¼ in. to 7 in. in circumference. Silver bracelets may be hammered up out of a piece of thick wire, one end being flattened out, cut, and twisted into scroll or other designs, the rest hammered square, being bent round to form the band. A box-setting, for a stone, soldered on to one side of the band, covers the joint and permits opening sufficient to pass over the hand.

The hinged band bracelet [30] is built up of square wire and sheet metal shaped on an elliptic brass pattern; or a piece of sheet metal is fluted with hammer-pane, annealed, flattened double, and drawn to required depth through an oblong-holed drawplate with a brass core. It is then bent to oval shape, the brass removed, and the front soldered in. Hollow tube bracelets are similarly made.

Flexible bracelets are built up of rings or links soldered together, the units thus formed being linked [29 and 31]. The figures show two of the simplest forms, illustrating the principle on which many compound bracelets are built.

Brooches are best kept rather small. They may be made on similar principles to pendants; or the base may be bent out of strip metal, with sharp angles, strengthened with solder, and the front and back soldered on.

The catch is made from a short piece of D-wire, filed flat at one end, coiled round at the other, and soldered in place on the brooch near the edge. The hinge consists of three short pieces of fine tube, to one of which the pin is soldered, the other two being soldered in line on a plate at a distance apart equal to the length of the piece of tube on the pin. Nine-carat gold is harder and more springy than silver, and is preferable to it for pins.

The *ring*, in principle, is simply a hoop of flattened or drawn wire, or a band of metal, coiled round a mandrel and soldered. But most of the rings sold—wedding, keeper, belcher, twist, signet, etc., are cast or stamped. Charcoal moulds are used on a small scale. Designs for table, etc., rings are built up on modelling wax out of the metal and stones, covered with plaster of Paris, the wax melted out, and the whole soldered together.

Setting Stones. There is much room for the display of skill in the setting of precious stones if their brilliancy, colour, and flash are to be properly brought out and inartistic contrasts avoided. For instance, the angle at which the stone is set varies with its kind. Stones are grouped together on the principles of identity, graduation in properties, or entire contrast. Stones which are similar do not accord well—for instance, the zircon is too much like the diamond to be associated with it, but the zircon accords well with the turquoise or green tourmaline, while the diamond contrasts well with stones that are waxy, internally reflecting (cat's-eye), less fiery, or pleochroic. Curved stones are best associated with step-cut. A single stone is sometimes mounted (in rings,

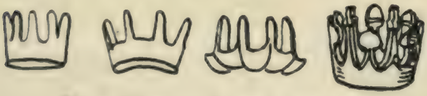
etc.), but it is more usual to set it with a border of small different stones.

The diamond may be set in gold, silver, or platinum, but the ruby, and other coloured stones, are set in gold. The ruby harmonises wonderfully with unburnished gold, or contrasts richly with dull gold, and it is a fault of modern jewellery that this characteristic of the ruby is largely ignored. Blue stones with yellow dead-gold settings give rich effects.

Backing and foiling with thin plates of gold, silver, tin, etc., is largely resorted to to improve the colour and lustre of poor stones. In the East, rubies are enriched by hollowing out the backs and filling with gold. Stones are never cemented in well-made jewellery. They are always retained in metal cups, boxes, claws, etc. A closed setting [32] is a box cut out of strip metal, the upper edge being turned over the stone with a burnisher. Open settings [34] are hand-made by cutting with a graver or drill and file a thick metal collet into claws, leaves, etc. A shelf for the stone is cut inside. Paved settings [33] are used only for the harder stones; they are liable to become loose. The setting is scorpered out of the solid metal with sloping edges, which are burnished over against the stone.

For *cabochon* stones, a conical setting carved in wreathed or other designs out of thick sheet metal is sometimes used. For rings and bracelets, settings are cut star-shaped into the metal, and the stone may be bedded in with a platinum collar.

Machine-made Jewellery. It is not easy to draw the line between mechanically-made and hand-made jewellery. Personal ornaments may be reproduced by the score from sunk dies by hammering thin sheet metal into the dies, but much skill is required, first, to cut the die, and then to carry out the repoussé operation and fit the article together. On the other hand, large quantities of articles produced in Birmingham have had expended upon them the slightest possible amount of hand labour. The design being settled, their production is



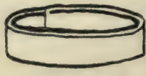
34. VARIETIES OF OPEN SETTING

merely a matter of machine stamping from rolled metal. These articles are known as "imitation" jewellery. The application of machinery to solid gold work is on the increase, but it is economically possible only where there is a large demand for a stereotyped article. Chains are very largely produced mechanically, and most ordinary rings are made in stamping presses. The production of the sunk steel dies used in pure machine-made and the class of jewellery referred to above is a matter requiring much artistic skill.

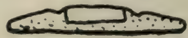
Hall-marking. Hall-marks are very complicated, and thereby fail almost entirely to serve the public, because expert knowledge is required to tell when or by whom an article was made, or where it was marked. The principal assay towns, or hall-marking cities, are London, Birmingham, and Chester. The London marks for gold plate are the sovereign's head and crown (if duty paid), the golden letter, indicating the year of marking (the series now running is in Roman small letters), number of carats fine, the leopard's head, and the maker's mark. For silver they are: lion passant, leopard's head, year letter, and maker's mark.

Certain articles, including jewellers' work containing stones, do not come under the heading Plate, and do not require to be marked. The testing consists in assaying about 5 gr. of alloy cut or scraped from convenient parts of the articles.

Old Sheffield Plate. This has been superseded by electro-plate, which is called "real" Sheffield plate. Very fine work was produced in the genuine ("old") plate, and it is now so rare that it is sometimes sold at prices exceeding the value of similar articles made in sterling silver.



32. CLOSED SETTING



33. PAVED SETTING

The plate used was made by bedding rolled fine silver with a hammer on to a planed copper ingot and then heating in the furnace (the silver face protected by a copper plate with a whiting-covered surface) till the silver melted and set on the copper. The ingot was rolled and worked by repoussé and hammering. Mounts, feet, and other additional portions were struck by dies.

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Continued

THE DENTAL MECHANIC

The Dental Mechanic's Training. The Student as Apprentice and Improver. Models and their Composition. Fitting Artificial Teeth

Group 7
DENTISTRY
3

Continued from page 5773

BEFORE taking up a more detailed consideration of the work which is done in the dentist's workroom, as apart from his surgery, it will be convenient at this stage to discuss the subject of dental mechanics as a means of livelihood, viewed altogether apart from the profession of dentistry in the wider sense in which the subject has hitherto been dealt with.

One of the great advantages which the education of the dentist affords consists in this, that at the outset of his student career he receives a practical training in a form of manual work, proficiency in which almost ensures good employment at mechanic's wages. This is a very real advantage because, under these circumstances, if the student is for any reason unable to complete his education at the hospital, he has the satisfaction of knowing that the elementary work which he has already done, although it stops short of the actual purpose for which it was taken up, is not by any means wasted. Should the student, therefore, after completing his period of apprenticeship, find himself not possessed of sufficient funds to carry him through his hospital course, it is of the utmost help to him to know that he has been building solidly all the time during which he has been apprenticed, and is now capable of earning wages which may well tide him over a temporary difficulty, and which, as experience increases, may afford a permanent means of livelihood.

Advantages of Practical Training. On the other hand, a young man who begins practical work in the dentist's workroom with a view to earning his living as a mechanic may subsequently find himself in a position to undertake the expense of a hospital education, and he has the satisfaction of knowing that the years he has spent in acquiring a thorough practical acquaintance with dental mechanics have brought him invaluable experience and manual dexterity, which will be of the utmost use in the study and practice of dentistry.

2. IMPRESSION TRAY FOR UPPER JAW

3. IMPRESSION TRAY FOR LOWER JAW

As a means of livelihood the work of a dental mechanic offers several advantages in addition to that which has been mentioned. The work is, perhaps, somewhat tedious and trying to the patience, but is certainly interesting to anyone who has a taste for occupation which demands manual skill and a mechanical turn of mind.

The hours of work are not long, averaging from nine or ten in the morning until five or six in the evening, with the usual midday interval. There is at present no overcrowding in the work, and a capable mechanic of steady habits is generally sure of employment, provided he is able to work well with his employer. The rate of wages is, on the whole, good, and, in addition to the ordinary form of employment as mechanic in a dentist's workroom, there are other openings for men with special qualifications. The dental hospitals appoint superintendents of their workrooms, with duties which generally involve the assistance and instruction of pupils and students in their work. Other dental mechanicians increase their earnings by fitting up for themselves a private workroom, and undertaking work for such dentists as do not employ a mechanic regularly on their premises.

The Young Dental Mechanic. For the guidance of parents who desire to bring up a boy as a dental mechanic a short outline will here be given of the course which should be pursued. All that has already been said as to the importance of early finger-training for a boy who is destined to be a dentist applies with equal force to the education of a mechanic. It is true that the course of training in the workroom is longer than that prescribed for the dental student; but a boy who begins this work with fingers to some extent accustomed to the handling of tools, even of the simplest description, will have a distinct advantage over one who has everything to learn.

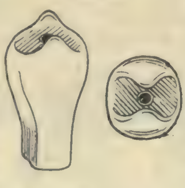
Very often it will happen that a boy must be put to learn his trade at the earliest date which the law allows, but, when it is possible, it is distinctly desirable that he should be kept at school after the recognised sixth standard and labour-test have been passed, or the prescribed age of fourteen years has been reached. A year's, or even two years', additional school-life will not tend to make him eventually any the less effectual a mechanic, while it will go far towards putting him in a position to study for the preliminary examination in arts which he may, as before suggested, subsequently wish to pass as the first step towards qualifying as a dentist. There may, indeed, be some difficulty in persuading a dentist to take as his apprentice a boy who has only just reached his thirteenth year, and in this case, if he be taken from school, it will be necessary to obtain for him some temporary light work which, unless it be well chosen, may tend to unsteady him and even unfit him for the life which has been chosen for him.

Apprenticeship. The period of school-life having drawn to a close, the next step is to arrange for his training in a dental workroom. For this purpose a qualified dentist should be approached, and, if possible, some acquaintance obtained with the dental mechanic employed with whom the boy will have to learn his work. The arrangements made between a dentist and the parents of such a boy vary considerably. The best plan is probably to enter into a definite agreement for the apprenticeship of the boy, the dentist undertaking to give him the opportunity of learning the work, and the parents paying a premium in consideration of this service. The amount of premium also varies, but

probably £20 would be about the average demanded, and is looked upon as an earnest that the work is to be seriously undertaken. The period of apprenticeship under such conditions would probably be five years, and it is usual for the dentist to pay the premium back in the form of wages, which gradually increase year by year. As an alternative, it may be agreed to dispense with the payment of a premium, the period of service being extended to seven years instead of five, and the boy being at first employed in more general work either in the workroom or house.

The Importance of Study. The plan first referred to has the obvious advantage of entailing a definite undertaking on the part of the dentist, and should be followed, if possible, where the boy has been kept at school for the additional time, as has been recommended. The second plan should be looked upon as the best that can be arranged where the funds necessary for the payment of a premium are unfortunately not available; it makes a more definite demand upon the boy's own enterprise and his power to give satisfaction to his employer. Many capable mechanics who have done well in their work have received their early training in accordance with the latter plan, and it is obviously to the advantage of the dentist to give a smart and promising boy every opportunity to learn his work well, so that during the later years of his apprenticeship he may receive from him good service in his workroom. During his apprenticeship a boy should be encouraged to continue his studies in the subjects of general education by attending evening classes, and the idea should be kept before him that some day he may have the opportunity of qualifying himself as a dentist, and that, therefore, he should make every effort to prepare himself as far as possible for the preliminary examination.

4 METAL DIE FOR STRIKING METAL PLATE



5 SECTIONS OF PORCELAIN "TUBE-TOOTH"

The Student as "Improver." The years of apprenticeship having come to an end, the next step is to obtain occupation as a mechanic. When the apprenticeship has been passed to the mutual satisfaction of both parties, a further engagement may be entered upon, and there are, of course, advantages in this plan. In other cases a position may be obtained in another workroom, and this has the advantage of giving opportunities of learning other methods of work than those to which the apprentice has been accustomed. So far as the apprentice is concerned, his choice should be determined by a consideration of his prospects in the workroom in which he has been trained. Technically, a young mechanic who has just completed his apprenticeship, and has obtained his first berth as mechanic, is known as an Improver; but the distinction concerns only the rate of wages which he is supposed to be worth to his employer. From this position he passes to that of mechanic. With the financial aspect of dental mechanics we have already dealt [see page 5773].

In preparing a set of artificial teeth to take the place of natural teeth which have been lost it is found both convenient and conducive to accurate working to carry out a great part of the process in the absence of the patient. This can be done if an accurate copy of the surfaces in the mouth to which the artificial teeth are to be attached be first procured. Such a copy is called a model.

Models and their Preparation. To obtain an accurate copy of the interior of the mouth the first step is to procure what is called an *impression*. This is essentially a reverse copy of the mouth, the result of pressing a suitable material against the surface of the teeth, gums, and palate so that they leave their impress upon the material. Various materials are used for this purpose. Their properties differ considerably, and the choice of the most suitable in any particular case demands careful consideration and nice judgment, which can only be effective when the operator is thoroughly familiar with the substances at his disposal. The materials in general use are these: Beeswax, gutta-percha, modelling composition and plaster of Paris.

The method of using the first three of these is to soften the material by means of hot water, press it into position in the mouth, and hold it firmly in place until, as the temperature falls, the material resumes its firm and stiff consistency. It should then be removed, if firm enough to retain its form without bending with the slight force that must be employed in order to detach it. Beeswax is used either in the pure form, or rendered tougher by the addition of resin, or mixed with colouring material to give it a more attractive appearance. It can be softened by a temperature which can be borne by the hand, and when in the soft condition should be kept below the surface of the water, and thoroughly kneaded into a soft and uniform mass.

Gutta-percha, of which the pure brown form should be used, requires a much higher temperature for its thorough softening, and the water used should be almost boiling. Great care has, therefore, to be used in order to avoid burning the patient's mouth.

Composition of Model Substances. Many attempts have been made to elaborate a material possessing all the properties of an ideal impression material, and for this purpose a variety of compounds is at the disposal of the dentist. Their constituents differ within fairly wide limits, and they possess somewhat varying properties. Most of them contain the following substances combined in varying proportions: A gum, of which gum *dammar* is an example; stearin, a fatty material; French chalk; carmine, or other similar colouring matter; and a perfume, such as otto of roses. Each of these constituents brings to the material some valuable property. The gum confers toughness, which enables the material to stand the strain of considerable force without fracturing, as a more brittle substance would; the fat renders the material capable of being softened by heat and thoroughly pliable when softened; the French chalk gives body to the whole, rendering it firm, giving a hold to the gum, and counteracting the too great plasticity of a hot mixture of gum and fat; the colouring matter and perfume are intended to render the material more attractive, and so minimise the disagreeable effects of placing a large quantity of this hot, soft material in the mouth.

Plaster of Paris is of an entirely different character. This is found in nature in the form of gypsum [see page 648]. The latter is purified and then slowly dried at a moderate temperature, with the object of driving off a portion of the water which is held in combination. The result is plaster of Paris

in the form of a soft powder, which has the property, when mixed with water, of taking up a definite quantity of the latter in combination, and so reverting to the hard, dense gypsum form. The time occupied by this process is approximately four and half minutes.

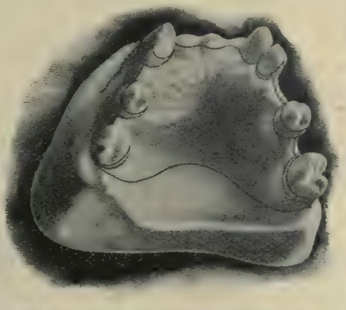
The Preparation of Plaster of Paris. Plaster of Paris is much used in the dental workroom, and serves a variety of useful purposes; it is of importance, therefore, that the best methods of using it should be clearly understood at the outset. To obtain the best results it is important to make a uniform mixture of the plaster with the water. For the finer operations, such as impression-taking, the best quality of plaster should be used in order to ensure uniformity of quality.

A small quantity of water should be placed in an earthenware or rubber basin, and plaster of Paris added carefully with a spoon until just enough has been placed in the basin to make a mixture of the consistency of thick cream. A little excess of water is generally seen upon the surface of the mixture, and this should be first poured off. The mixture is then thoroughly stirred with a spoon, and any lumps which may by accident have been formed should be carefully flattened out and thoroughly incorporated with the whole. The plaster is now in a condition to receive an impress, and, after being placed in the desired position, should be held firmly in place until it has set, and then carefully removed.

The process of taking an impression is necessarily disagreeable to the patient, and it is therefore desirable to reduce as much as possible the time during which the impression material must remain in the mouth. This can be effected, in the use of the first three materials named above, by cooling the surface of the material for a moment just before inserting it into the mouth, and by syringing the mouth, or sponging the material while in the mouth, with cold water. Cooling the material in this way accelerates the process of hardening, and thus reduces the time occupied by as much as one or even two minutes. In dealing with plaster of Paris a similar result can be achieved by the use of warm water in mixing, and still more effectually by the addition of a little common salt, or, better, a little potassium alum, to the water before incorporating the plaster of Paris with it. The use of alum in the mixing of plaster has another distinct advantage in that it controls, and to a large extent prevents, that expansion which takes place in plaster of Paris as it is setting, and which tends to introduce an element of inaccuracy into the results obtainable.

The Importance of Accuracy. The importance of obtaining in the first place an impression of the mouth which shall afford a copy of the surface required as nearly perfect as is possible cannot be overestimated, for the most skilful performance of the later processes of the work can never compensate for, or overcome, the faults of the original model. In respect of accuracy, there can be no doubt that plaster of Paris is a far more efficient impression-taking material than the others mentioned, and this can be readily demonstrated by anyone who will take the trouble of experimenting with the materials, as by obtaining a copy of the fine lines and furrows of the thumb. There are, however, other considerations of a technical nature which concern the dentist rather than the dental mechanic or pupil, and which will in many cases determine the choice of material in favour of one or the other substances, of which the various compositions are especially useful. From the point of view of the mechanic and pupil, the work begins when the dentist puts into their hands the impression which he has obtained from the patient's mouth. The impression is contained in a small metal cup or tray so shaped as to fit the jaw and to retain the impression material and prevent it from spreading too far or escaping into the mouth. Two types of trays are required, the one being adapted for taking an impression of the upper jaw, the other being adapted to the lower jaw [2 and 3]; a variety of sizes is also required, since there is a good deal of difference in the size of the jaw in individuals.

Making the Model. The mechanic, having been supplied with an impression, which is virtually a reverse copy of the jaws, has first to make a "model," or true copy, of the surfaces to which the artificial teeth are to be attached. This he does by using the impression as a mould, and pouring into it some fluid plaster of Paris. The same care should be employed in order to obtain a uniform mixture as enjoined above. A small portion of the mixed plaster is first placed in the impression, and well shaken into place, so that every portion of it is filled, and any bubbles of air broken up. A second portion of plaster is now placed on the bench, and the two portions united by turning the impression upside down: the plaster is then smoothed and trimmed with sloping sides, care being taken that the tray is fixed horizontally.



6. PLASTER OF PARIS MODEL OF UPPER JAW

When the plaster has completely set, the impression in its tray has to be removed. If, in taking the impression, use has been made of one of those materials which are softened by heat, the separation is readily effected by placing the whole in a basin of hot water for a few minutes, and then pulling off the softened material. If, however, the impression has been taken in plaster of Paris, it is necessary to prevent a complete adhesion between the plaster of the impression and the fluid plaster poured into it to form the model. This is effected by washing the plaster impression over with fine oil or a solution of soap in water to which has been added a little colouring matter, such as carmine. The fluid plaster is then poured into the impression, and the model formed as described above.

When the plaster is thoroughly hardened, the whole should be plunged into hot water, the metal tray is then detached, and the plaster of the impression is chipped away with a penknife, the colouring matter serving as a guide to direct the chipping-away process. The model thus obtained is now cut to shape by trimming away surplus plaster and carefully smoothed until it takes the form shown in 6.

The Metal Plate. If it is decided that the teeth shall be supported upon a metal plate to be worn in the mouth, the model is at this stage slowly dried in an oven, and then dipped for a few minutes in some melted stearin. This serves to render the surface smooth and not easily rubbed or injured. With a pencil the model is then marked to show the

extent to which the jaws and palate are to be covered with the metal plate; and with these marks as a guide, a piece of thin paper, or, better, a piece of lead beaten out very thin, is then cut of the exact size of the plate required. Taking this as a pattern, the metal is cut to size.

Of the metals used for this purpose gold plate 18 carats fine and of gauge No. 7 for the upper jaw, and of about No. 9 for the lower jaw, is the most serviceable for general use; but under certain circumstances an alloy of silver and platinum may be advantageously employed. In order to make this plate take the desired shape it is necessary to employ a model of greater strength and durability than plaster affords, and for this purpose metallic models must be obtained. These are called *dies* and *counter-dies*.

Die Making. The die is a duplicate of the plaster of Paris model. First a ring of iron is obtained, of about 5 in. diameter, ½ in. in thickness, and 3½ in. in height. The model is carefully dusted with powdered French chalk, and then placed upon the work bench and surrounded with the iron ring. Some fine sand is then moistened sufficiently to render it slightly plastic and capable of binding, in much the same way as snow binds in a snowball. This is firmly packed into the ring around the model and above the latter until the ring is filled flush with its rim. The ring and its contents are now reversed upon the work-bench so that the base of the model becomes uppermost.

The next step is to remove the model from the sand. This is effected by attaching a small handle to the base of the model by means of shellac, and withdrawing the model carefully by this handle, the model being in the meantime continually tapped with a small hammer in order to detach small particles of sand which may adhere to it.

But it is not always possible to obtain an accurate and satisfactory impression of the model in sand in the simple way just described. It will be found that many models present inequalities and overhanging parts, technically known as *undercuts*, which, if the sand were packed round the model in the manner described, would obtain such a hold on the sand that the model could not be withdrawn without breaking away a portion of the sand impression. When these inequalities are present only in parts of the model which it is not desired to reproduce in the metal die—as, for instance, along the outer sides of the model—the difficulty is readily overcome by filling up the inequalities flush with the general surface by means of beeswax softened by heat. The wax is then carefully dusted with French chalk to prevent adhesion to the sand. It will not infrequently happen, however, that the jaw takes such a form that even the parts that it is most important to reproduce accurately will present undercuts, which constitute a serious difficulty. This may be dealt with satisfactorily in some cases by tilting the model within the sand-ring at a judicious angle before packing the sand around it; but in other cases resort must be had to a device which is technically known as *core-making*.

Core-making. The model is carefully oiled to prevent adhesion, and a small portion of a mixture of plaster of Paris (two parts), fireclay (one part), and water, is then placed upon the model so as to fill up the undercut or dovetailed portion of the latter. While "setting" the new plaster is carefully trimmed to such a slope that it offers no inequalities which can hold it in the sand, and the little mass is then split into two or more pieces of such a shape that they can be separately removed from the model. These pieces are known as "cores." They are placed in position on the model after being carefully dried, and the whole used to obtain an impression in sand. When the model is withdrawn the cores remain attached to the model and can readily be placed separately in their true position in the sand mould, and the result is an accurate reverse copy of the model. The sand reverse, having been obtained by one or other of the methods described, is then used as a mould, into which is poured molten metal.

Metals used in Making Dies. Of the metals used for this purpose zinc possesses general properties which render it on the whole the most serviceable. Two or three such metal dies and counter-dies will be necessary, since they tend to deteriorate under the blows of the hammer or the swaging process to which they are subsequently subjected, and it is often of advantage to have at least one die and counter-die made of a different metal, such as tin, or of an alloy of tin with antimony in the proportion of of five to one, or of tin and zinc in the proportion of two to one. Such dies are more resistant than those made of zinc or lead, and are of great use in giving the metal plate its fine fitting to the model. Using these dies, reverses or counter-dies can be obtained by placing the die again within the casting-ring, and packing slightly moistened sand round, but not over, the die. This leaves exposed the parts of the zinc die to which the plate has to be fitted, and if this is carefully dusted over with French chalk before further molten metal be added, the two portions of metal can be separated when cool [5]. For the counter-die lead, or an alloy of lead with tin in various proportions, is generally used. The metal should be melted down in a large cast-iron ladle placed over a gas-stove, and to prevent contamination different ladles should be used for the different metals or alloys employed. To obtain the best results it is necessary to take care, first, to moisten the sand to the right degree; secondly, to avoid oxidising the molten metal by overheating; and, thirdly, to pour the metal when it is sufficiently fluid to pour readily and yet so cool as to be almost solidifying.

The Arrangement of the Teeth. Dental mechanics is so largely concerned with the attempt to reproduce natural conditions, and supply, by artificial teeth, the place and position of natural organs which have been lost, that it is of the highest importance that anyone who undertakes this work should make himself thoroughly familiar with the conditions which prevail naturally.

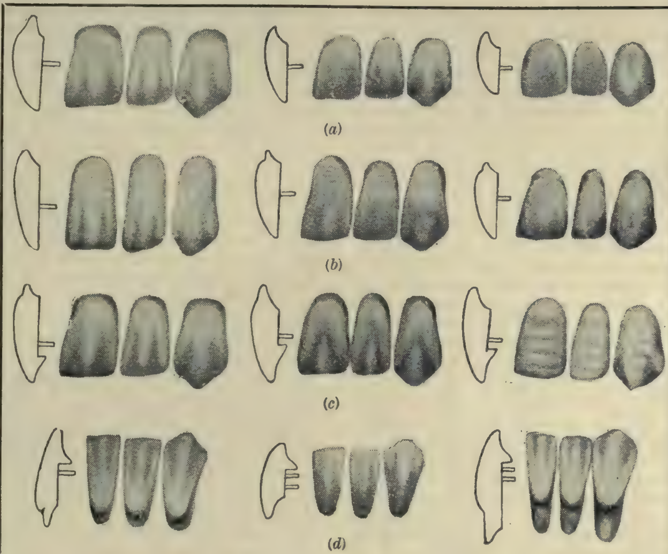
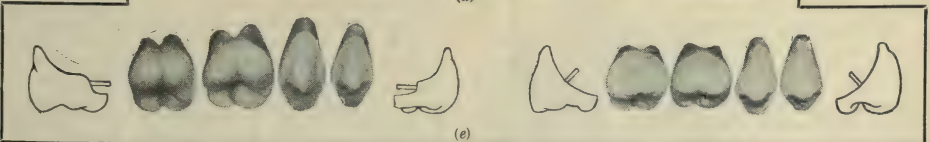
The arrangement of the teeth in a healthy, well-armed mouth is found to be that which is best adapted to the work which the teeth and jaws have to perform, and in providing artificial substitutes the best results are obtained when the general scheme of the natural teeth is closely followed. Mechanical laws are, indeed, found to underlie the arrangement which Nature has selected, and these laws apply generally when the natural teeth have given place to those made of porcelain. If, then, the skull of a normal healthy adult with well-formed jaws and a complete set of natural teeth be carefully examined, a knowledge of the conditions prevailing and the principles involved may be obtained, which will constitute a useful guide when the artificial denture, as it is called, has to be constructed.

The teeth, then, are seen to number thirty-two, there being sixteen in the upper and the same number in the lower jaw. The general conformation of the jaws and the arrangement of the teeth thus render it apparent that each jaw is divisible into a

pair, there being a right and a left side. The two sides correspond very closely; in each the teeth are set upon a heaped-up ridge of bone which runs round the jaws and forms its margin. The general arrangement of the teeth on each side is that of a curved line, so that the two sides combine to form, not a circle, but an arch, of which the part which is seen from the front fairly represents a part of a circle, while at the back the two extremities open out to form, as it were, two horns. It is next seen that the various teeth differ within fairly wide limits in respect of their general shape and size, and here, again, the jaw is symmetrical, so that a description of one side will apply equally to the other. Starting, therefore, from the mid-line of the mouth in front—that is, at the summit of the arch—we find, first, three teeth with sharp cutting edges, followed, as we trace the bony ridge round the mouth, by five teeth of an entirely different kind, their general shape being that of a cube with a broad, roughly square surface, which, when the mouth is closed, fits against the similar surfaces of the teeth in the opposite jaw [7].

from this circumstance. In this region the curve begins to correspond to a circle of somewhat larger circumference than that which obtains in the front of the mouth, and, as we progress backwards, the line gradually departs further and further from the circle.

After the canine come two teeth which closely but not perfectly resemble each other; these are called "bicuspid" teeth, owing to the circumstance that their chewing surface, which varies from oval to square in general outline, carries two cusps or blunt points, which fit in with similar prominences on the teeth of the opposite jaw. The line of teeth is completed by three large "molars," massive teeth with a large grinding surface, upon which are four or five prominences or cusps. The last tooth of the series—that is to say, the third molar—is popularly known as the "wisdom tooth," as it does not generally appear until years of discretion have been reached. In the mouths of the majority of people in modern civilised communities it is distinctly smaller than the other molars, and is frequently lost by decay soon after it has appeared.

7. SELECTION OF PORCELAIN TEETH

a and *b*. For upper metal plates *c*. Upper vulcanite plates *d*. Lower vulcanite plates *e*. Upper and lower vulcanite plates

Generally speaking, we may say that the first three teeth serve the purpose of cutting or tearing the food, while the last five crush and grind the pieces of food between their opposing surfaces. More particularly described, the first or "central" tooth in the upper jaw is a broad tooth with a long and sharp cutting edge, the general shape being that of a wedge. The second or "lateral" corresponds with it fairly well, so far as general build is concerned, but is considerably narrower. In the lower jaw, the central is even narrower than the lateral [7]. The third or "canine" is a long, prominent, and strong-looking tooth, with its cutting edge carried up into a point; it bears some resemblance to the corresponding tooth in the mouth of carnivorous animals, such as the dog, and derives its name

An *artificial denture*, as a set of teeth is called, attempts to reproduce all, or any, of these teeth in a natural position, except the wisdom tooth, which is considered unnecessary, and can be omitted for the sake of making the denture as light and as little cumbersome as is consistent with efficiency.

The artificial teeth used by dentists are made of porcelain, which is placed in a plastic condition in moulds formed from natural teeth which have been extracted, and is then fused at a high temperature. The teeth are supplied by manufacturers, who make them in an immense variety of shapes, colour-shades, and peculiar forms to imitate natural conditions. As the artificial teeth are to rest on the gums, instead of being inserted into the jaws as the natural teeth are, they, of course, have no root or fang, consisting of crown only. In the process of

their manufacture, two small pins, made of platinum, are fused into the body of the tooth, and it is by means of these pins that the artificial tooth is attached to the plate on which they are supported. It is very necessary that the dentist should have at his disposal a very large selection of artificial teeth from which to choose a set for each particular case. The natural teeth vary within enormous limits, there being marked differences not only in size and general shape and curious individual markings [**7**], but also in the manner in which the teeth are disposed along the ridge of the jaw and in relation to one another.

Selecting the Teeth. It is commonly thought that all artificial teeth should be small, of a pearly translucency, and arranged in a perfectly regular sequence around the jaws; but no opinion could be more completely erroneous. A set of artificial teeth of this kind is not only in many cases positively ugly, but it gives at once the appearance of being utterly out of place in the majority of mouths, and at once reveals to an ordinarily observant person the patent fact that the teeth are not natural. In natural conditions, it is very common to find one tooth in the front of the mouth slightly overlapping its neighbours, or standing forward somewhat prominently, or, again, set in the jaw at an angle not perfectly corresponding to that of the other teeth.

These slight irregularities, present sometimes on one side of the mouth, and in other cases symmetrical, give character and expression to the teeth, and their absence often robs of all its individuality a smile that would otherwise be charming. Suitability of colour is, again, of great importance. There are men whose general build, physique, and complexion would lead anyone who was accustomed to observe what conditions prevail naturally to expect to find broad, yellowish, bony, strong-looking teeth; while in other cases long, slender, almost transparent teeth, slightly blue at the tip, would seem essential to a proper conformity with the rest of the features. In the selection of teeth, therefore, it will be seen that there is a scope, and indeed a demand, for the exercise of no little judgment, based upon careful observation and directed by trained artistic perception.

Fitting the Teeth. In the workroom these porcelain teeth have to be fitted to the plaster model which has been obtained in the manner described. When the patient is young, and in cases where the natural teeth have not been entirely lost, there is generally a strong and prominent bony ridge around the margin of the jaws; in such cases the best results are obtained by carefully fitting the porcelain teeth to the gum in such a way that they appear to grow out of it, as natural teeth do. To this end the porcelain tooth must be slightly shortened, and that part which is nearest the gum, and is called the neck of the tooth, must be cut so that it exactly fits against the surface of the gum. The cutting and fitting is done by grinding the edge with a small stone wheel, which is carried on a lathe worked either by treadle or electricity. Stones of various sizes are used, and it is best to have several kinds ready for use, some for rough cutting, others for fine fitting and smooth finishing.

When the teeth have been fairly recently extracted, the model generally shows slight indentations along the ridge which corresponds to the gum, and serve as guides for the placing of artificial teeth. As soon as the latter have been roughly fitted into place, it is best to place on the model, in and around the indentations, a little paint composed of carmine or vermilion and oil. If this is done, and the artificial tooth then placed in position, a little paint will adhere to the base of the tooth, indicating the spot at which the tooth actually touches the model. The tooth should then be ground away a little at this point to enable other parts of the base to fit into their place.

Artificial Gums. In the mouths of old people, and especially when all the teeth have been lost, a peculiar change takes place in the bony ridge, leading to its absorption or diminution, so that the jaws present an almost flat surface. In such cases it is undesirable to fit the artificial teeth to the gum, for reasons which will be obvious, and it becomes necessary to provide a substitute for the bony ridge on which the teeth should be supported.

This substitute has two functions to perform. It has to prop out the lips, and so prevent that shrunken and falling-in appearance which is so characteristic of toothless old age; and it has to support the artificial teeth in a natural position. It is, of course, very desirable that whatever material is used should resemble the natural gum as closely as possible, and be so arranged around the necks of the artificial teeth as to give a natural appearance when shown, as it is likely to be in smiling. For this purpose vulcanised indiarubber, with which a suitable colouring matter has been incorporated, is generally used.

How the Plate is Fixed. The teeth having been selected and fitted to their place, the next step is to decide in each particular case how the plates carrying the artificial teeth may best be retained in their proper position in the mouth. There are three chief methods of attaining this end, known as the methods of adhesion or suction, of clasps, and of springs. The method of adhesion depends upon the fact that if two surfaces which fit accurately to each other be moistened, and then closely applied to each other, so that there is no intervening air, atmospheric pressure will tend to hold them together so that they cannot easily be displaced by a direct pull at right angles to the surfaces. A plate carrying artificial teeth and accurately fitting against a large portion of the palate and gums will, in many cases, be sufficiently adhesive to retain its place.

This method is specially useful in dealing with mouths in which all the natural teeth have been removed, as in these circumstances it is possible to obtain a more perfect fit, and the dentist is deprived of the assistance which can be derived in other cases by the use of clasps. These clasps are small bands or catches made of springy gold plate, 16 carats fine, and of gauge No. 8 in thickness, which are bent with the pliers to a shape suitable for clasping the natural teeth [**4** and **6**]. One or more of the natural teeth on each side of the jaw are selected for this purpose. The clasps, which have been fitted in this manner, are then fastened to the plate which is to carry the artificial teeth, and serve to attach the plate to the natural teeth when the plate is in position.

It occasionally happens, however, that the dentist has to deal with a case in which no natural teeth are standing, and in which the force of adhesion is insufficient to retain the plate. In these circumstances he has to resort to springs, which are coils of fine gold wire, about $1\frac{3}{4}$ in. in length, and about $\frac{1}{16}$ in. in diameter. The ends are attached to small swivels inserted into the upper and lower plate on the same side of the jaw. On each side of the jaw the spring, therefore, forms a kind of hinge upon which the plates open and shut.

Continued

THE ART OF MACHINE PRINTING

Group 19
PRINTING
7

Continued from page 5747

Making Ready on the Machines. The Wonderful Hoe Rotaries. How a Newspaper is Printed. The "Self-Educator" Machine. Jobbing Work. Art Printing

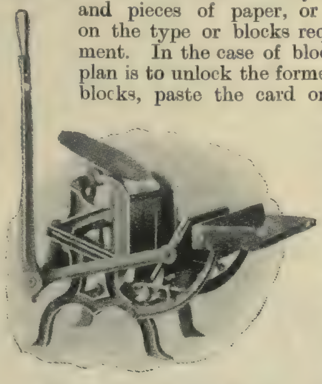
By W. S. MURPHY

THE wonderful perfection of printing machines notwithstanding, the pressman is still the indispensable artist, without whose touch good work is impossible. The ancient pressman packed the inside of the tympan with cloth and paper, and overlaid the front of it to bring up a level impression. In respect of this branch of our art we have made very little advance. On improved hand press, on single cylinder, on perfecter, and on platen machine, packing and patching must be done.

Making Ready on the Hand Press. The object aimed at in packing the tympan of the hand press block [42] is to put between the type and the platen a solid, smooth, and elastic pad, thus finely graduating the impression. Some printers fill the tympan tightly, but that is a bad practice, tending to slacken the skins. Take about a dozen sheets of thin, rolled paper, of size that fits nicely into the frame, lay half of them smoothly on the bare skin, fold a flannel sheet, so as to make three plies of the proper size, and lay it on. Put the rest of the sheets in, and fix the frame. No one, of course, works with a bare tympan face. For every job a new sheet of paper is pasted on it. Paste carefully round the edge of the paper, to the breadth of half an inch, and lay it evenly on the skin, firmly stretching it. If you have time to let it dry, a damped sheet will give a sheet as tight as a drum, and much nicer to work than a slack one. The cutting of the frisket is a simple operation, and calls for no guidance. Simply take a heavy impression of the page or pages, and cut out the impression.

Overlays. Except in newspaper establishments, the overlay is the best part of a pressman's work, and we may here consider it broadly, for the principle is the same in all printing machines. However well made, type shows little irregularities, especially if it has been used. All forms of type do not require the same impression; a broad-faced type needs a stronger impression than a small, sharp type; even in books, four or five different faces and sizes of type may be in a page; given a perfectly true tympan, or platen, or cylinder, these inequalities of the type must be made up. The overlay is the sheet or sheets of paper patched up to make the page appear even and uniform. Having taken an impression, you mark all the inequalities, and put pasted patches of paper, thin and thick, as may seem necessary, on it, then paste the whole sheet evenly on the tympan or cylinder. If, after graduating the patches to the very best of his ability, the pressman finds his impression seamy, he should paste a clean sheet over the overlay, thus smoothing out the lines. Coarse patching is a serious fault, however, and cannot be palliated by any device. For fine work, as many as four overlays may be required. Beginners blunder in forgetting the fact that all impression is relative. The object to be aimed at is balance. A weak impression in one part is not to be corrected at the expense of the impression which is just, and by raising the weak impression you may lower the part which was strong. The best plan is to try to find the medium, and work round it.

Underlays. Sometimes the inequalities on the surface of a page or sheet are too great to be overcome by patching an overlay. No overlay should exceed, at any one part, the thickness of a strong sheet of paper. Where more is needed something else must be done. Badly worn type, stereotype plates, and blocks badly mounted or printed beside type, give low impressions, and brass rules give high ones, which can hardly be corrected by the overlay. The last is made even by a device of its own; but blocks and low lines of worn type are helped by what is called the underlay. The forme must be lifted and carefully brushed over, and pieces of paper, or card, pasted on the type or blocks requiring treatment. In the case of blocks, the safer plan is to unlock the forme, lift out the blocks, paste the card on the bottom needed to bring them to the proper height; then lock up the forme again, plane it down firmly, and make a trial impression.



42. MODERN HAND PRESS

Bearers. Brass rules do not wear down so readily as type, and they have sharp ends. These rules are used to make the lines which compose tables, or divisions of sections of pages, and when printed with type are apt to cut deeply when the rest of the forme may give a good impression. To remedy this, the pressman resorts to *bearers*, pieces of lead called *clumps*, made type high, set outside the forme even with the brass rules. As their name signifies, these bear away the weight of the impression at those particular points, and make the brass rules print equally with the type. When the figures of the page folios stand

far out from the body of the page, or short and broken pages make up the forme, bearers are needed to carry off the weight of the impression.

Register and Casting. It is a canon of the printing art that consecutive pages should lie square, one on the other. This is termed *register*. To obtain register easily, the pressman has made tools named *points*, long thin pieces of iron, shaped like a screw-key, with a point sticking up in the handle. These are fastened with small screws in the very centre of the forme, one at each side, and make two holes in the sheet as it is printed. If the pages of the forme have been properly imposed, the pins will enter the same holes when the sheet is reversed. As a consequence, the pages will fall correctly on the back of the pages corresponding.

The sheets of books and newspapers are printed rapidly on both sides, one side after the other, and the ink on the sheet first printed, being wet, leaves a mark on the second cylinder which grows blacker with every impression. If left alone, the one side of the sheet would quickly present the appearance of having been printed twice and become a mere mass of smudges. Preparatory to starting work, the pressman soaks thin sheets of paper of the size required in benzene or oil, dries them, and as soon as his tympan or cylinder shows signs of *casting*, pastes one on, renewing the sheet as necessary. The oil or benzene absorbs the ink, and keeps the pages clean.

Getting Ready to Print. In the old days the forme was locked up on the hand press by means of wooden furniture and sidesticks. Later, however, the hand press was fitted with a chase, slotted on the inner sides, and fitted with steel bars, one of which was a double wedge ; the bars could be fitted to any size of forme. On the platen of the press a notch marks the centre, and by means of a gauge the centre from front to back is best found. Then the quoins are driven in, and a touch with the mallet and planer sets it on its feet, or ought to. Meanwhile the pressman's assistant has taken a portion of ink from the can, and smoothly spread it along the back half of the table. He lifts down his roller, and lets it touch the ink, rolling it firmly on the table till the smooth zinc is a glistening black. When the roller is fully clad, the inker is ready to begin. The paper is banked, and the bench bared to receive the printed sheets. All the other operations have been already described, and we now let the pressman lay on his sheet and begin work.

Preparation of Cylinders. For cylinder machines there are two methods of packing, soft packing and hard packing, both of which have special merits. Soft packing is the older method, and is still preferred for general work. At each edge of the opening in the cylinder are fixed two steel bars. These are the clinchers of the cylinder packing. Loosen and take them out. Have a large piece of calico, capable of covering the cylinder when doubled ; double it ; lock the one side within the bar and pull tight, gripping it at the other side. Paste together at one end about a dozen thin sheets of paper ; fix in, and draw them taut over all but the blanket, which is then put in. Brush the type-carriage table well ; lay the forme in, and lock it round, giving it a gentle smoothing with mallet and planer. Though the forme may be properly placed, the cylinder may either crush heavily on it or fail to touch it. To adjust this is to find the *pitch*, according to the slang of the trade. Every size of forme has its own pitch. But a gauge should lie ready to the pressman's hand, which gives the pitch of the machine for every size and margin. If not, put a spot of ink on the edge of the cylinder, and turn slowly, setting the forme in position so that the ink will touch the impression bearer. The margin has been obtained, but the impression may be too light or too heavy.

In the first place, the attempt should be made to lighten the impression by taking off some of the packing on the cylinder, or by putting more in to make it heavier ; but if that does not serve, the regulating screws at each end of the cylinder must be slackened to lighten, or tightened to deepen the impression. As the balance of the cylinders in many machines is so easily lost, and so difficult to recover, the practice of resorting to the screws to change the impression is not one to be recommended to beginners.

In hard packing, simply stretch a sheet of fine cardboard in place of the calico, use glazed paper for the packing, and instead of the blanket, put a strong sheet of glazed paper on top. Hard packing gives a fine clear impression, and serves very well for printing light blocks ; but the cylinder has not the resilience and smoothness in running desirable in high-class book-work.

Inking Up. At the end of every ink table of a cylinder machine is the ink-duct, well filled with ink, and geared so as to give out a regular supply to the mixing rollers working beside it. The outlet is governed by a set of screws in the back of the duct, and the pressman can restrict or enlarge the supply at will. The best arrangement is that which gives seven rollers to the forme, arranged three and two and two ; the mixers or vibrators, that never leave the table, two that run up to nearly the head of the table and just cover the forme, and two that roll over two-thirds of the ink-table and overrun the forme. The first set of rollers mix the ink, the second carry a large share of ink to the type, and the third spread the ink well over the type and table. The table must be clear as a dark mirror, and the rollers free from lumps and skins of ink, or those dirty black spots called *monks* will appear on the sheets and spoil the work ; on the other hand, the pale *friars* will show on the pages if the ink is stinted in supply or the rollers jump.

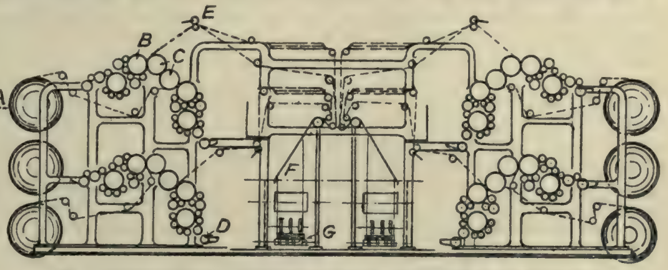
These directions form the basis of practice in all printing establishments ; at this point, variation begins, the character and class of work in each place determining the divergence. Firmly grounded in the principles of his craft, the printer is able to adapt himself to the particular requirements of any office.

Ninety Thousand Papers an Hour. It is in newspaper production that the most wonderful developments of the printing trade have taken shape and arrived at a high pitch of efficiency. Perhaps the highest achievements of modern mechanical genius are to be seen in the machine-room of the newspaper. Stage by stage, the newspaper printing machine has been developed, till, at the present time, from myriad complex engines driven at enormous speed, newspapers, folded, cut, and ready to read, pour forth in a continuous stream.

The difference between a rotary machine and a cylinder machine consists mainly in the fact that while the latter is a cylinder revolving on a flat type-carriage, the former is a series of cylinders, sheet and type cylinders, running on each other, pair by pair. Obviously, a higher rate of speed can be developed by two rollers running together than by a cylinder acting with a flat surface losing contact every revolution.

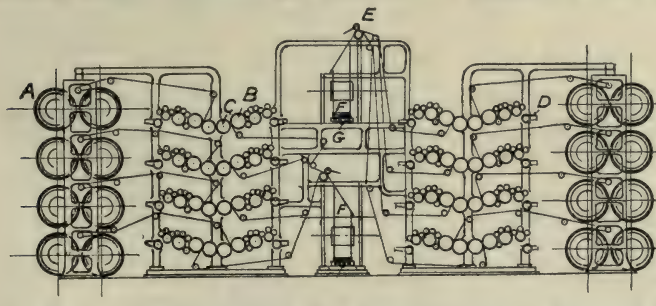
The Rise of the Rotary. Colonel Hoe, of New York, was the pioneer in the production of the rotary machine. In 1848, Hoe erected a rotary for "La Patrie," of Paris, and some time after installed an improved model in a London newspaper office. Fascinated by the promise of immense speed in the rotary machine, inventors on both sides of the Atlantic were soon busy devising new machines on that principle. In 1865, William Bullock, of Philadelphia, devised an apparatus for feeding a rotary machine with the web of paper, producing the first automatic printing machine. In 1866, the proprietor of "The Times," and his staff, built the Walter Press, printing from the web. Another forward step was made by the invention of the "Victory Web Printing and Folding Machine," by which the automatic character of the printing machine was practically completed. The rest of the story is a record of the competitive efforts of rival engineers, each one trying to go one better than his rivals. Messrs. Hoe continued to add improvements to their machines, and the "Hoe" as it at present stands is probably the most perfect of its class.

Here and there the printer may come into charge of some of the lesser known machines; but those most in use are the Victory, the Marinoni, the Whitefriars, the Cottrell, and the Hoe, and to these we will devote detailed attention.



43. LONGITUDINAL SECTION OF AN OCTUPLE HOE ROTARY
A. Paper roll. *B.* Type cylinder. *C.* Impression cylinder. *D.* Ink fountain
E. Slitter roller. *F.* Folder. *G.* Delivery

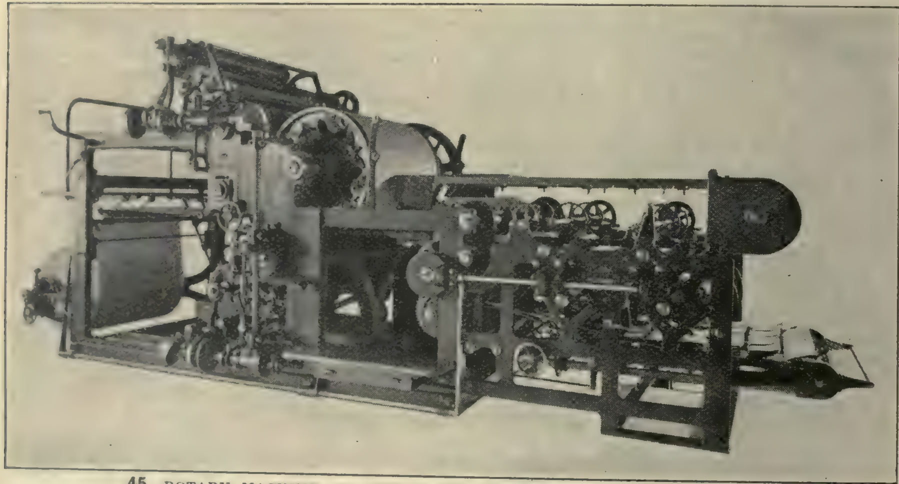
The Victory. The Victory is a very complete rotary machine, and prints at the rate of 12,000 copies per hour, delivering them folded and ready. The type and impression cylinders revolve on each other in the centre of the machine. At the back, hanging clear of the floor, is the paper web, damped on both sides by a couple of ingeniously contrived sprays. The damped paper travels high overhead to the centre of the machine, where it descends to receive its first impression on the inner forme, and winding round the impression cylinder it is carried up between the second pair of cylinders, there receiving the second and perfecting impression. Thence, on small guiding rollers, the continuous sheet is conveyed through the cutting cylinders, and into the human-like fingers of the folding apparatus. The inking arrangements are well conceived. Behind each type cylinder range a series of rollers, extending from each ink-duct. First a feeder roller, then four vibrating rollers turning on the ink cylinder, and next, two rollers running between the type and ink cylinders.



44. LONGITUDINAL SECTION OF A DOUBLE OCTUPLE HOE ROTARY
A. Paper roll. *B.* Type cylinder. *C.* Impression cylinder. *D.* Ink fountain
E. Slitter roller. *F.* Folder. *G.* Delivery

The Marinoni Rotary. Without its delivering apparatus, the Marinoni would closely resemble a calendering machine [see page 5747]. Ink-duct and rollers, type and impression cylinders, and again inking apparatus, are piled above one another. The two midmost cylinders are the agents of impression; above and below them revolve the type cylinders, and at top and bottom, ranged in a graded series, are the inkers. It is worth while noting the separate features of this machine.

At the back of the body of the machine hangs the paper web, from which the paper winds under the damping apparatus and up between two smoothing rollers into the tier of cylinders. Led round the upper impression cylinder, it is brought into contact with the higher type cylinder, and then passes down between the lower pair, and through the cutting cylinders, thence with automatic precision to one and another of the four delivery boards in succession. Like all rotary machines, the Marinoni is well furnished with inking rollers. From the ink-duct, sitting well within the machine, four rollers act on one another as mixers, the last of the series playing in contact with the ink cylinder, round which run three small rollers in addition to the pair of distributing rollers revolving between the type and ink cylinders. The original Marinoni has been greatly improved. For certain classes of work the cutting cylinders can be reversed and made to cut the paper before it enters on printing, and a gearing has to be worked in sheets on hand. The plates have been curved, screwed on the cylinder, the impression adjusted, and the inking rollers placed. A feed board lies above each end of the machine, and on these the sheets are laid, the smooth side up on the one, and down on the other. It should be said that the machine is fully taped to guide the sheets and send them out straight. When the machine starts, the sheets follow each other, one from each board alternately, at the rate of 4,000 an hour, and run through between the cylinders, coming out on to the descending tapes, and beaten flat on to the receiving board at the bottom by a flyer hinged near the base of the machine. Fitted up for a newspaper, the Whitefriars has its feeding boards taken off. Instead, a web is hung under the fore end of the machine, and a pair of cutting cylinders, with knife, geared in front of the feeding apparatus. If it be desired, a folding and cutting apparatus can be worked just above the delivery board for a newspaper.



45. ROTARY MACHINE, ON WHICH THE "SELF-EDUCATOR" IS PRINTED

been devised whereby two rolls of paper hang behind the machine, keeping up a constant supply, the one coming into use as the other is exhausted, and the empty roll being replaced by a fresh web.

The Whitefriars. Originally intended to be a fast perfecting two-feeder, this machine has been adapted to the web, and may be described as a useful medium between the newspaper and the book machines. In shape the Whitefriars differs greatly from all the other rotaries. It resembles a bridge, the four principal cylinders resting on the arch. The plate cylinders, which are in the centre of the structure, are curved spirally, with grooves cut and under-cut, so as to enable the screw-catches to travel to any part of the cylinder, and hold the plate securely. The size of the plate is of no consequence, as the grooves are set so that a very small job may be worked, and the plates may be thick or thin. Suppose, first, we have a small book

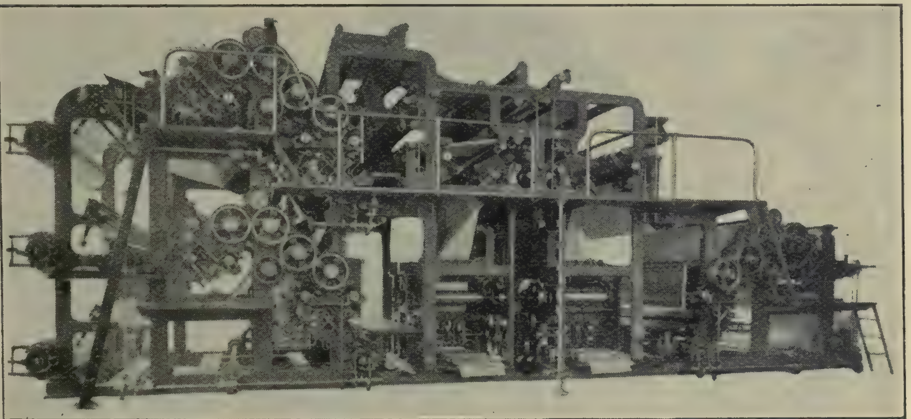
The Cottrell. The Cottrell rotary is principally used for printing illustrated magazines, and it is on this machine that the SELF-EDUCATOR is printed [45]. It is fitted with a patent shifting tympan for preventing off-set, and prints 64 pages folded and delivered in four 16-page signatures. The cylinders are 54 in. in circumference, taking a web 40 in. in width.

The Hoe. Nothing could be more instructive to the student of printing than to glance into the textbooks of the printing trade, and study the description given in each of the Hoe machine. The machine described is the one in use at the time at which the book was written, and it will be found that the dates of publication very nearly correspond to the successive stages in the development of this marvellous combination of many inventions. The machine named the quadruple Hoe [46] is probably the finest and most efficient machine at present working. Though designated quadruple, it has, in many

instances, been converted into a sextuple machine, capable of producing eight-page papers at the rate of 72,000 per hour. The octuple Hoe [43] will produce the same at 96,000 per hour, while the double octuple [44], with eight folders, will turn out 192,000 of the same papers in the hour.

The Printing of the "Daily Mail." About the time when the London streets begin to darken, the newspaper printing machines are preparing to start. The student will remember that in our section on stereotyping we left the curved newspaper plates cleared and fined [page 5557]. Thus cleared and fined, the plate next passes on to the boring box. Specially made for the purpose, the borer describes the same arc as the surface of the machine cylinder, and the bed is the size of the "Daily Mail" page. Protected by zinc, the plate is put face downwards in the circular bed of the box, and fixed. The knives cut to the proper depth the ribs formed on the ribs of the mould, and at the same time the cooling plate is pressed to the uniform size. Now the plate is ready, and it joins others on the hoist, to drop down into the hands of the machine man far below in the basement. Every hour 100 plates are sent down those hoists. An average of 550 plates is produced in a single night, using about three tons of metal. We follow the plates to the basement. Along the walls blocks and tackle, running on overhead rails, bear huge reels of paper, and stop in front of towering machines. Through the centre of the reel a geared spindle is run, and is fixed in place by circular wedges. With the help of the hydraulic wall crane, the reel is laid on the machine. Up among the cylinders in the heart of the quadruple machine [46] the men are busy. One by one the stereotype plates come, and are sent on the cylinders. When all are in place the men come down, the paper from the reel is led in, and all is ready. By touching a small wheel hung horizontally on a vertical shaft depending from the side of the machine, the leading machine man calls on the electric power, and the machine moves. The motion is slow, and after the paper has gone through, it stops while the foreman or his assistant swiftly scans the sheet. If the colour, impression, and register are good, the word to start is given. In a few moments the mass of machinery is flying at terrific speed; the white paper runs off the reel and into the dark maze of cylinders, while from under the folders at the other side comes a cataract of printed, cut, and folded papers.

Commercial Work. The jobbing printer is the man-of-all-work in his trade. He is the general servant of the trading public. Account tops, memorandum forms, trade circulars, price-lists, and advertisements of many sizes come his way. Such a variety of work puts a strain on a workman's invention, if he tries to do it well. Very often the feeling of a task too great induces slovenliness, but jobbing firms have grown from small to great because the heads of the firm and the staff made every little job a study. Good printing can be produced as cheaply as bad printing. To equip himself for his work, the jobbing printer has to study every detail of the trade. For him the hand press and hand rollers, the numerous varieties of type, the mysteries of making ready, imposition, and even stereotyping and the cylinder machine, are necessary.

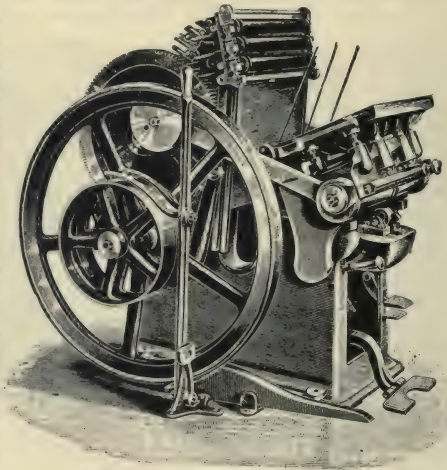


46. SEXTUPLE HOE ROTARY, ON WHICH THE "DAILY MAIL" IS PRINTED

Display. The jobbing compositor has a wider range than the jobbing office; he appears in the book office and the newspaper establishment. Advertising has largely developed during recent years, and the demand for novel and artistic design will continue to grow. The first requisite of the display compositor is a thorough knowledge of the relations of the various sizes of types to each other and the character of type faces. Because he works with letters, the printer is apt to forget that his work has a pictorial value. The general effect of a poster, for example, if rightly designed, will tell the passer-by the relative importance of the items advertised even before he has read it. Newspaper advertisers,

employing, as they do, a costly medium, want value for their money, and the designer of the advertisements has it in his power to help or hinder the fortunes of his paper. The first aim should be clearness, the second boldness, and the third, but not least, artistic unity.

Platen Machines. Most jobbing offices utilise the platen machine to a greater extent than any other. It is at once a very simple and useful machine [47]. Within a frame the two main parts are set perpendicularly facing each other, the one half holding the type-carriage, rollers, and inking apparatus; the other, the impression platen and feeding-board. Locked in a special chase, the type is laid vertically into the carriage, and fastened with a bracket screw. The rollers, fixed in spring forks, move up and down from the inking table on top, over the type, and back again, driven by a rod at the side. When at rest, the platen lies at an angle of 45°, face up. It thus offers a clear opening to the feeder, and is otherwise easily managed. The paper being laid in on the platen, the machine starts, by treadle or power, and the steel shaft fixed on the pinion wheel draws the two parts together, while the cam block under the platen lets it slip to the vertical position. Naturally, platen and type meet, and with turning of wheel and cam are brought back again to the start. The principle of making ready on the platen is the same as that for cylinder machines. Every different model has special features of its own, but these can readily be learned by a little practical observation.



47. TUDOR PLATEN MACHINE

Colour Printing. Two-colour, three-colour, and sometimes four-colour posters, handbills, programmes, or other jobbing work come to the printer. Let us suppose the printer has undertaken to print a poster in red and blue. His best plan is to set up the type as if for a one-colour job. After the bill has been set up, the lines for the different colours are marked, and the bill divided into two sections, a skeleton being made of each. The blue lines are filled up on the red forme with furniture the size of the type, and the red lines have a similar substitute in the blue forme. If the first forme is properly printed, and the second forme, accurately gauged, is laid exactly in the place of the first, the result will be a two-colour bill as regular in its lines as if it had been printed in one colour. No matter what may be the class or character of the work, the working principle is the same. Accuracy and cleanliness are the chief requirements in colour printing.

Bronzing. Gilding, or bronzing, is accounted one of the fine arts of printing; but the process is simple, and easily learned. With good bronze dust, two brushes, one for laying on the bronze and one for clearing, a clear varnish, a clean, hard roller, and type faultlessly clean, the printer can produce fine bronzing. The type is lightly and evenly rolled with varnish, and the sheet printed. Over the wet varnish the bronze, taken up in the brush, is gently laid, and then wiped off and rubbed up with the clearing brush. Many printing firms fail to produce good gilding, and the secret must either lie in poor quality of materials or bad workmanship. Clever boys have been known to produce beautiful work.

Art Colour and Block Printing. In the realm of art the oldest and newest methods of printing meet. While it may be said that art colour printing has been carried on for a long period, the trade has only become important through the advent of the electroplate and the process block. The latter, indeed, has given a new meaning to art colour printing. Process blocks are reproductions of pictures photographed on plates of copper, and bitten in with acids. The absolute accuracy of the photograph gives the printer any number of plates equal down to the minutest detail. To modify these for key-block or outline, and the successive colour blocks, is a matter comparatively easy. With the production of the blocks the printer has very little to do. [See PHOTO-ENGRAVING.] His business is to print well the blocks supplied. In colour printing register is obviously of the highest importance. Every plate must fall exactly on the plate printed before it. To make sure, in addition to the points on the formes, drawing pins are fastened point outward in the tympan or cylinder. Overlaying is carried to the finest point in the printing of blocks, both black and colour. As many as five or six skeletons are frequently made for the overlays of blocks. First, the high lights are cut out and the deep shades patched; then gradually the scheme is worked till every little detail of the picture is effectively brought out.

Continued

KEEPING A POULTRY FARM

Profitable Poultry-keeping. The Scientific Basis of Egg Production. Poultry Manure as a Side Line. Houses and Runs. Cramming

POULTRY
continued from
page 5706

By Professor JAMES LONG

POULTRY FARMING, as distinct from ordinary poultry keeping, can as yet scarcely be described as a distinct industry in this country, Many attempts have been made to carry on work on isolated lines, with the result that there have been many failures. The farming of poultry, however, in conjunction with some other industry, is a practical affair, and one which can be carried on with complete success

Profitable Poultry Keeping. There are various ways of keeping large quantities of poultry with profit: (1) in conjunction with corn farming, stock farming, dairy farming, market gardening, orcharding, and, indeed, all industries the basis of which is the land; (2) as a distinct occupation, (*a*) the fowls being kept in confined runs, and (*b*) the fowls having full liberty. Mistakes have been made by persons who do not understand the subject, in renting large areas of poor land under the impression that liberty was all that was required. But this is a mistake; poultry, like other domestic stock, thrive best on good land, where they find a much larger number of insects and animal life of other kinds, as well as plenty of clover and other rich and nourishing herbage. The best plan, however, is to keep poultry on the ordinary farm, using movable houses, and at such a distance from each other that the birds will not mingle in the breeding season, nor be induced to stray and lay where their eggs may be lost or stolen. Where it is necessary to keep hens in confined runs, these runs should be large, the grass rich, and planted with half-standard fruit trees, or even, in the absence of fruit, with standard roses, or plants of any kind which are suitable, and which are able to return a paying crop. The wire fencing itself may be made the medium of the cultivation of either fruit or flowers which may be trained, or which will naturally climb. The poultry farmer is not able to pay the rent of good lands over which his birds may roam at liberty unless it is cultivated and grazed or cropped. The movement of large numbers of poultry is sufficient alone to spoil a grass crop intended for hay, so that in most seasons it may not even be worth the cutting.

Grain food for poultry should be purchased in the wholesale market, as at Mark Lane. The ration should at least three times per week consist partly of meat or bone, and a supply from a dealer in horseflesh should be arranged for. If the paunch of the sheep or bullock can be obtained, well cleaned and cooked, this will be found the best form of animal food.

Weight and Composition of the Egg. The weights of the average egg of the various British and French breeds of poultry were carefully taken by Lemoinne, the French expert, as follows:

	oz.	grs.		oz.	grs.
Brown-red Game	2	99	Langshans	2	69
Buff Cochins	2	20	Polish	2	22
Leghorns	2	99	La Flêche	2	20
Crèvecœur	2	33	Courtes Pattes	2	68
Houdan	2	83	Grey Bresse	1	39
Black Bresse	2	36	Guinea Fowls	1	13
Gournay	2	20	Hamburghs	1	30
Silver-grey Dorkings	1	41			

The composition of the egg as ascertained at the agricultural experiment station of New York State was as follows:

Twenty-nine eggs analysed (Ratio in feed of albuminoids to carbohydrates. as 1 to 7·27; ratio of ash to total dry food, as 1 to 51·3): Average, water, 72·83; fat. 11·06; albuminoids, 1 ·36; ash, 0·87; total solids, 27·17.

Eleven eggs analysed (Ratio in feed of albuminoids to carbohydrates as 1 to 3·81; ratio of ash to total dry food, as 1 to 27): Average, water, 75·22; fat, 9·28; albuminoids, 12·78; ash, 1·45; total solids, 24·79.

Twenty-two eggs analysed (Ratio in feed of albuminoids to carbohydrates as 1 to 7·24; ratio of ash to total dry food, as 1 to 51·1): Average, water, 74·27; fat, 9·94; albuminoids, 12·79; ash, 0·74; total solids, 25·73.

89. MOVABLE HOUSE, SHOWING OUTSIDE NEST BOX

In this experiment the birds were fed upon different mixtures of food, in order to ascertain which yielded the best result, albuminoids, or flesh formers, as albumin, fibrin, gluten, and casein, being allotted in different proportions to the carbohydrates, or heat givers and fat formers, as starch, sugar, oil and fat. No eggs were analysed until the feeding had been continued for three months. The average per fowl is given on the next page.

Pen	Proportion of albuminoids to carbohydrates in feed	No. of eggs	Average weight of one egg in grammes
1	1 : 3·7	12·50	55·01
2	1 : 7·27	33·75	55·67
3	1 : 3·8	12·25	53·70
4	1 : 7·24	41·42	52·89

A large proportion of starchy or fatty foods, such as maize, appears, therefore, to be most favourable to egg production.

SPECIFIC GRAVITY OF THE EGG.

	Eggs			Eggs	
No. 1. Average of	40..	1·088	No. 4. Average of	34..	1·091
,, 2. ,, ,,	24..	1·086	Brown-shelled ..	..	1·087
,, 3. ,, ,,	11..	1·095	White-shelled ..	..	1·092

PER CENT. OF SHELL IN FRESH EGGS

	Eggs			Eggs	
No. 1 Average of	40..	9·98	No. 4. Average of	50..	10·86
,, 2. ,, ,,	43..	9·95	Brown-shelled ..	..	9·96
,, 3. ,, ,,	21..	10·78	White-shelled ..	..	10·82

90. LEAN-TO HOUSE AND RUN

PROPORTIONS OF WHITE AND YOLK (SHELL FREE).			
		White per cent.	Yolk per cent.
No. 1.	Average of 40 eggs	63·95	36·05
,, 2.	,, ,, 43 ,, ...	65·21	34·79
,, 3.	,, ,, 21 ,, ...	65·33	34·67
,, 4.	,, ,, 50 ,, ...	62·38	37·62
	Average	64·22	35·78

Analysis and Weight of Poultry Manure. The following figures represent the analyses made by the late Dr. Voelcker, and by the great German chemist, Emil Wolff.

	Fresh.	Partially Dried.
Moisture	61·63	41·06
*Organic matter and ammonia salts ..	20·19	38·19
Tribasic phosphate of lime (bone phosphate)	2·97	5·13
Magnesia, alkaline salts, etc.	2·63	3·13
Insoluble silicious matter (sand)	12·58	12·49
	100·00	100·00
*Containing nitrogen..	1·71	3·78
Equal to ammonia	2·09	4·59

—	Water	Organic Substance	Nitrogen	Phosphoric Acid	Potash	Soda	Lime	Magnesia	Sulphuric Acid
Egg (ash 9·2)	737	–	20·0	3·5	1·6	2·1	1·0	0·1	–
Pigeon dung	519	308	17·6	17·8	10·0	0·7	16·0	5·0	3·3
Fowl	560	255	16·3	15·4	8·5	1·0	24·0	7·4	4·5
Duck	566	262	10·0	14·0	6·2	0·5	17·0	3·5	3·5
Goose.. ..	771	134	5·5	5·4	9·5	1·3	8·4	2·0	1·4

In an investigation made by Messrs. E. and W. Brown, at the poultry farm connected with Reading College, the weight of manure produced by various kinds of poultry, together with its composition and money value, were approximately ascertained, and the work was so good that it deserves to be recorded for reference. First, four fowls, which were fed in confinement, were tested, their weights being as follow. A. Wyandotte cock, weight 6 lb. 12 oz., age 16 months; B. Faverolles hen, weight 5 lb. 12 oz., age 15 months; C. growing chicken, weight 3 lb. 12 oz., age 14 weeks; and D. fattening bird, weight 3 lb. 8 oz., age 15 weeks.

In one week in June, A produced 1 lb. 13 oz. of manure, equal to 26·8 per cent. of the weight of its body; B, 1 lb. $11\frac{1}{4}$ oz., equal to 29·6 per cent.; C, 1 lb. $2\frac{1}{2}$ oz., equal to 30 8 per cent.; and D, 1 lb. $13\frac{1}{4}$ oz., equal to 52 per cent. Thus, in twelve months A would produce $94\frac{1}{4}$ lb., and B $88\frac{1}{2}$ lb., so that 24 fowls similar to A would yield a ton in a year, containing 38 lb. of dry matter per bird.

Quantities and Values of Poultry Manure. In a similar test with an Aylesbury duck weighing 7 lb. the manure produced in a week was 6 lb. $10\frac{3}{4}$ oz., equal to 346 lb. in a year, or 76 lb. of dry matter. The turkey tested weighed 17 lb., and produced 4 lb. $1\frac{1}{4}$ oz. of manure in a week, equal to 212 lb. in a year, containing $53\frac{1}{2}$ lb. of dry matter. Thus it would take $6\frac{1}{2}$ ducks or $10\frac{1}{2}$ turkeys to produce a ton of fresh manure. An adult goose produced 10 lb. 1 oz. of manure in a week, equal to 523 lb. in a year, containing 91 lb. of dry matter, so that four geese would produce nearly a ton of fresh manure in twelve months. The composition of the manure varied remarkably. That of birds at liberty contained 59 per cent. of moisture and 40 per cent. of dry matter, while that of the birds in confinement contained 68 per cent. of moisture and 31 per cent. of dry matter, which was much richer in nitrogen than either of the previous

samples. The manure of ducks contained 78 per cent. of moisture and 22 per cent. of dry matter; of geese, also at liberty, 82 per cent. and 17 per cent., and of turkeys, 74 per cent. and 25 per cent. The manure of the goose was much the poorest of any, while the manure of chickens six months old was much poorer than that of the adult fowls, and the remark applies in a lesser degree to that of chickens one month old. We take one example—that of poultry at liberty: the composition of the manure was as follows: moisture, 59·5; dry matter, 40·5; containing nitrogen, 1·75; containing phosphoric acid, 1·00; containing potash, ·54

Estimating nitrogen to be worth 12s. per unit (1 per cent. per ton), phosphoric acid 3s., and potash 4s., Messrs. Brown further estimated the value of fresh manure per ton at 26s. 2d. for fowls at liberty, 21s. 10d. for fowls in confinement, 32s. 5d. for fattening fowls, 19s. 5d. for ducks, 8s. 4d. for geese, and 16s. 2d. for turkeys. Supposing, therefore, we take the value of the manure produced during the life of a laying hen extending to 2½ years, we find from the same experimenters that it reaches 2s. 4¾d.

Poultry-houses and Runs. Some words are necessary in order to define the requirements and the form of construction which poultry-houses of various types should take. Where poultry are kept in large yards, the runs surrounded by wire or iron fencing, the houses are usually fixed. It is, however, very convenient to construct them so that they can be moved at will, for the ground is quickly tainted, and protection may be afforded against wind and rain or against a too powerful sun. There is, however, the advantage in a fixed poultry-house [91] that the floor can be specially prepared. The earth should be removed to the depth of at least a foot, fine strong wire netting, through which a rat cannot pass, being laid along the bottom and fastened to the plates on which the house is fixed. On the top of the wire ballast, or chalk may be placed, covered with sand, and finally with dry loam. This can be daily raked for the removal of the manure, after which, when necessary, it may be re-sanded, or fresh dry earth distributed, the soil being an excellent deodoriser. Such a house will be practically vermin proof.

Movable Houses. The movable poultry-house in the limited run may be provided with wheels, and these are now manufactured so that the wheels are lifted when the house is at rest; or with two pairs of arms, a pair at each end, thus enabling a couple of men to move it when required. Where movable houses are employed in the fields, they should be of larger construction, sufficient to shelter from 50 to 70 hens [89]. Each house should be lightly but strongly constructed, especially for securing the birds against theft. There should be perches fixed 1 ft. or 2 ft. above the floor, according to the size of the birds, and nest boxes, which may be examined from the outside of the house if necessary, a lid covering them, secured by a padlock. In some cases, movable houses are provided with wooden floors, removable for cleaning, about 18 in. from the ground, the space beneath, which is enclosed on three sides, becoming a shelter for the birds [94].

In all cases it is essential to provide light and ventilation. The ventilation should be above the perches, so that the birds do not roost in a draught. Light is essential, for many reasons; it prevents an accumulation of germ life, while it induces the birds to leave the perch earlier in the morning and to seek it later at night.

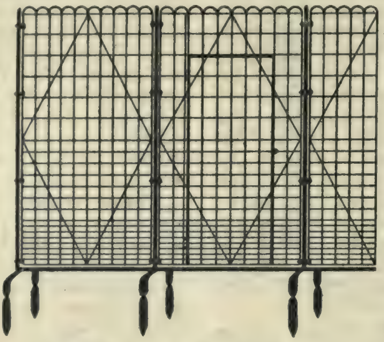
Fixed Houses. The lean-to house [90] is one that is generally constructed in the backyard or garden of limited space. It is built against a wall or fence, from which the roof slopes forward. In such a case there should never be many hens kept together, six being ample. A run should be attached, and like the house itself, roofed and wired in front, wire netting of a strong gauge and medium-sized mesh being employed. The floor of the house and run in this case should be at least 6 in. higher than that of the yard or garden outside, and made in a similar manner to that already described. Where no roof is provided for a run, the soil quickly becomes foul and unhealthy, and, indeed, no one should attempt to keep hens in a limited space under such conditions.

91. FIXED HOUSE AND RUN

Making Poultry-houses. The material employed in making poultry-houses may be either matchboard, tongued and grooved, or for cheaper houses, rough feather-edged board, which can be subsequently tarred. Matchboard can be painted and more easily preserved if it is well put together. The roof of a house may be of wood, tile, slate, thatch, or iron; wood will usually be selected, as being the simplest and most inexpensive, iron and slate

being too hot in summer, while thatch provides a harbour for vermin, and is easily set on fire. A wooden roof may be protected by paint, tar, or tarred paper, subsequently sanded, or even by tarred felt.

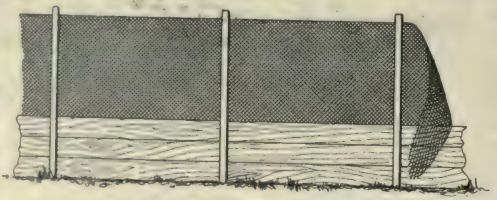
Whether a house should be ready-made, or built by a neighbouring joiner, or even by himself, the owner must decide; unless he is expert with tools, he will find it a much wiser plan to visit one of the great agricultural or poultry shows, where there are large displays of houses and other appliances by manufacturers, many of which are extremely ingenious, priced at a comparatively low figure. There can be no doubt that a ready-made house, easily taken to pieces or put together, can be purchased in this way at a lower cost than it can be constructed by an ordinary joiner.



92. WIRE HURDLE FENCING

Small Houses and Fencing. Poultry-keepers who exhibit their birds at exhibitions are compelled to keep single cockerels, or adult cocks, in small houses and runs by themselves. A single house may be divided for this purpose into three compartments. It should be lean-to in shape, with a perch across the centre, a small door at the back, and an opening in the front for the bird to pass into the wire-covered run provided. In a house divided into three compartments, a run with a partition must be arranged for each. Without a partition, the birds would see each other, attempt to fight, and damage their plumage, comb, and ears. These houses should be movable, for, their size being extremely limited—about 2 ft. × 2 ft. 3 in. for a bird of medium size—the grass is quickly soiled, and they require a change.

In constructing the fencing which encloses poultry runs on which hens are kept for laying or breeding purposes it is important that the standards should be substantial. They had better be of squared oak, at least 4 in. × 3 in., the part let into the ground being doubly tarred or creosoted. In some cases, however, iron standards are employed, small grooves being made in each rod where wire is to be fastened. The fencing material may either be very strong galvanised meshed wire [93], carefully strained and pegged to the ground, or galvanised iron hurdles [92], which are made for the purpose, to various patterns and in different sizes. These are more easily taken down and re-erected, but they are very costly. Strong diamond netting is sometimes employed, but this, too, is costly.



93. WIRE NETTING FENCING

Rearers and Brooders. Rearers and brooders, like incubators, should be purchased from a good maker. Great advances are being made in this work. In some cases large breeders construct houses facing the south, the whole front being glazed, within which are long, narrow runs, carefully sanded and fitted at the back with hot pipes which pass from end to end of the building, thus warming a number of compartments, in each of which a large number of young birds is placed. This system is also adopted on a much smaller scale for the warming of movable brooders [95], a lamp being employed to heat the pipes.

There is, however, much difference in the requirements of the breeder. The beginner may be satisfied with a large packing-case, provided with a good lid and ventilated by the aid of a centre-bit sufficiently large to produce a number of round holes placed two-thirds of the height from the ground. The floor of the box may be sanded, or knocked out altogether, but in this case the soil should be perfectly dry, and kept clean. A good lamp being provided, a piece of perforated metal may be converted into a cylinder that it may be covered entirely, and kept in the centre of the box, so that when they require warmth, the young birds may collect around the cylinder, and enjoy the heat which the lamp produces. Between this home-made affair and the elaborate heating system to which we have referred are many stages and modes of rearing young chickens which may be examined at exhibitions already referred to, or in manufacturers' show-rooms. In all cases, however, cleanliness is the next essential to warmth, if, indeed, it is not equally as important.

Cramming Pens and Coops. Fatting pens which are used in the artificial fattening of poultry are generally constructed in rows, and placed under shelter out of cold winds and rain, and as far as possible kept at a temperature of 58° to 62°. Fatting birds are more successfully fatted when kept in small companies of half a dozen or so. The size which is recommended for the pen is from 18 in. to 20 in. high, and from back to front, by 30 in. in width. Each pen is practically constructed of wooden bars $1\frac{1}{2}$ in. apart, those composing the floor being shaped so that the bottom of the bar is much narrower than the top, this preventing the manure clinging to them—and, indeed, facilitating its passage below. The birds are fed in the fatting pens from troughs for

about half the time they are under the feeding process, cramming then continuing to the end.

The illustrations we have provided indicate that there is a great variety of hencoop [see page 5092] in the market. A coop should be of planed wood, painted each season, the object being to exclude vermin, as well as to keep it in repair.

Fattening for the Market. The system of artificially fattening chickens for the table, which has so long prevailed in France, is now extensively adopted in this country. The best birds for fattening are those which have been well fed when at liberty, and are healthy and already plump. They should, if possible, be of the best table breeds, or crosses of those breeds. The birds should be from twelve to fourteen weeks old, and as large as possible. Although this is the programme of English and French feeders, there is in Western America a poultry farm on which, incredible as it may appear, 40,000 Leghorns, a small, non-table breed, are fed for market purposes with success. The feeding period lasts from fifteen to twenty-one days, the latter not being exceeded, for birds when ripe for market should be fed no further, and killed after twenty-four hours' fasting, whether they have reached two or three months in age.

94. MOVABLE HOUSE

Fattening Food. Whatever the breed, fattening chickens must not be of an excitable nature, nor possess crooked breasts. After twenty-four hours' fasting, they are put into the feeding-pens and fed twice daily for about ten days, when cramming begins. The food supply should consist of Sussex ground oats, barley meal or wheat meal, mixed with new milk, or, in its absence, skimmed milk, to which, in either case, a little cheap mutton fat is added. This is at first given in very small quantities, $\frac{1}{4}$ oz. per day, but it should not exceed $\frac{1}{2}$ oz. daily. The troughs must be carefully cleaned, and the birds supplied at each meal with newly-prepared food mixed to a thin dough. Some persons use mixtures of ground oats, with toppings or fine sharps or barley meal, maize meal, or buckwheat meal; experience will, however, show what mixture answers best. The cost of the food supplied should not exceed 6d. for the whole period.

Cramming. When cramming commences, the birds are fed either by machine, by the aid of a funnel, or by hand. The meal is made into somewhat stiff boluses, which, after dipping into milk, are passed by the thumb and forefinger of the right hand into the gullet, and worked into the crop until it is full. Where the funnel is used it is placed in the mouth of the bird, and a cropful of thinner paste passed down. Similarly, where the French cramming machine is preferred the paste is made sufficiently thin, and is passed into the crop through the mouth, in which a nozzle is placed. The quantity, being regulated, is forced into the crop by the pressure of the foot upon a treadle.

Preparing for the Market. The birds make their chief gains a few days after cramming commences. Little improvement is effected in the first week, and not much more in the last, weight being chiefly put on during the middle period. Three weeks' fattening in this way should increase the weight of an average bird from $1\frac{3}{4}$ lb. to $2\frac{1}{2}$ lb. Killing, which is performed in various ways—and we think the bird should first be stunned before the knife is employed—picking, shaping, and packing for market, should be carried out in careful accordance with the requirements of the salesman.

95. GLAZED CHICKEN BROODER

Arrangements having been made to deliver birds to a salesman, the greatest care should be exercised to exclude any that are imperfectly fattened or which are below the weights for which a contract or arrangement has been made.

AGRICULTURE *concluded ; followed by* BEE-KEEPING

Group 10
TELEPHONES
2

Continued from page 5684

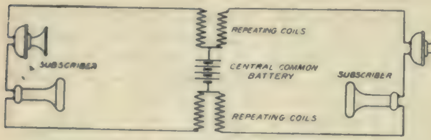
CENTRAL ENERGY SYSTEMS

Repeating Coils. Lamp Signals. Traffic Arrangements. Subscribers' and Junction Switch Sections

By D. H. KENNEDY

Central Battery System. Coincidently with the progress already described, attention was being directed to another important problem. From the point of view of maintenance, the most troublesome feature in a subscriber's telephone set was the battery. Many attempts were made to devise a system which would replace the numerous subscribers' batteries by one central source of energy located at the exchange, where skilled supervision was available. The problem bristled with difficulties, but these were gradually overcome, and several equally good solutions are now in existence. Probably the most popular is that of Dr. Hammond V. Hayes, the main feature of which is the use of a special form of repeating coil. It is really a small transformer [see page 1657], with four equal windings, each having 3,000 turns and 40 ohms resistance.

The Repeating Coil. Every pair of connecting plugs and cords in a central energy exchange of the Hayes type includes one of these transformers, arranged as shown in 11. The central battery is of accumulators, 11 in number, giving approximately 24 volts. The resistance must always be very low, and is only a small fraction of an ohm. The two subscribers' transmitters shown are each fed with the current from the main battery. During conversation variations produced in the A side are repeated by the action of the transformer to the B side, and vice versâ. Hundreds of such repeating coils may be connected to one battery of adequate dimensions without any interference from pair to pair occurring. This is attributable, first, to the low resistance of the battery; and, secondly, to the fact that the windings of the repeating coils are arranged so that they oppose their inductance to any alternating currents entering from the battery.

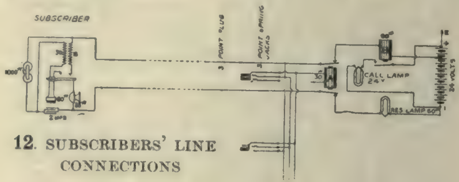


11. PRINCIPLE OF CENTRAL ENERGY EXCHANGE

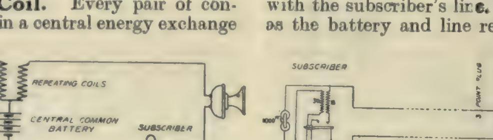
Connections of Subscribers' Line and Cord Circuit. The diagrams [12 and 13] will enable us to consider in detail the arrangements both at the subscriber's station and at the exchange.

The subscriber's apparatus consists of a transmitter, a receiver, an induction coil, a magneto bell, and a condenser. In the normal position of the automatic switch only the bell and condenser are joined across the lines. The exchange ends of the lines, it will be observed, are connected to the battery through a line relay, and the connections pass through the double armature contacts of what is known as a "cut-off relay." Normally, owing to the presence of the condenser, no current flows. When a subscriber lifts his receiver he brings his transmitter and one of the induction coil windings across the line; the current from the battery flows, the line relay B [12] is energised, and its armature connects the signal lamp across the battery, the lamp glows, and so attracts the attention of the operator.

Answering. It is desirable that the lamp, having fulfilled its purpose, should now be put out, and this is arranged for by utilising the test wire and introducing the cut-off relay A [12]. The sleeve of the operator's three-way cord is in connection with the battery, and when the operator inserts her answering plug a current flows through the cut-off relay, and continues to do so as long as a plug is in connection with the subscriber's line. This puts out the lamp, as the battery and line relay are now cut off from the subscriber's line, so far as this path is concerned. Simultaneously, however, a new connection with the battery is established by means of the tip and ring of the plug and two windings of the repeating coil. The "ring" conductor has in circuit a relay. This is the answering cord supervisory relay. In order that the presence of its inductance may not act deleteriously, it is provided with a non-inductive double-wound shunt. When the operator connects with the waiting subscriber, this relay is energised. Its armature connects the 40-ohm shunt across the terminals of the answering cord supervisory lamp. So long as the subscriber is at his telephone this relay is energised, and the lamp is dark because of the shunt. The restoration at any time by the subscriber of his receiver to its normal position on the automatic switch allows the supervisory relay armature to drop back and causes the lighting of the lamp, the current flowing from the negative pole of the battery through the 83½-ohm resistance coil, the lamp sleeve of plug, bush of jack, test wire, and cut-off relay. A similar arrangement exists on the calling cord side. The lamps in the cord circuits are 12-volt lamps. The student should note that the 83½-ohm resistances are necessary to enable a sufficient variation to be produced by the shunt.



12. SUBSCRIBERS' LINE CONNECTIONS



13. CENTRAL ENERGY CORD CIRCUIT

The Operator's Set. In the circuit of the calling plug there is included a combined listening and ringing key. The operation of the listening key bridges across the circuit, the operator's receiver, and one winding of the induction coil. A two-microfarad condenser is included, so that the supervisory relay is not actuated. The operator's transmitter is connected directly to the main 24-volt battery. A 140-ohm retardation coil is in circuit, in order to reduce the voltage at the terminals of the transmitter to 5½ volts. A two-microfarad condenser is joined across the terminals of the primary coil and transmitter, to provide a path for the fluctuating currents. The operator speaks to the answered subscriber through the medium of the repeating coil. The operator's transmitter is of the breastplate pattern, made of aluminium, and weighing only a few ounces. The headgear receiver is provided with a band to hold it in position, and it is also very light. These are shown in **14**.

14. HEADGEAR RECEIVER AND BREASTPLATE TRANSMITTER

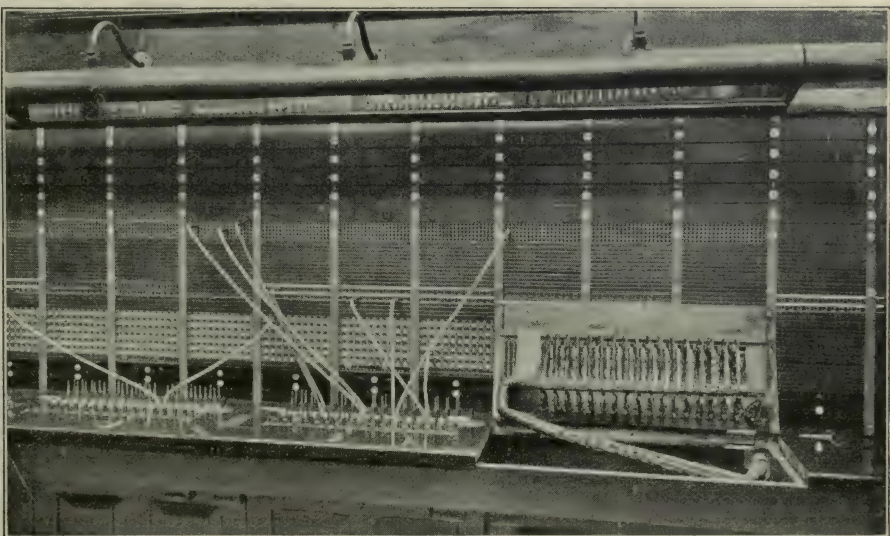
Engaged Test. Having ascertained what number is required, the operator tests to ascertain if the subscriber is disengaged by raising the calling plug and pressing its tip against the bush of one of the subscriber's jacks. It is clear from what we have already stated that if the subscriber is connected for speaking at any point, the test wire will be "live," and on touching it there will be a click in the operator's receiver.

Calling. If, on the other hand, the line wanted is disengaged, no click will be heard, and the operator will press home the plug and press forward the key, in order to call the subscriber. Ringing currents from the exchange generator will pass out to line, and will actuate the magneto bell at the subscriber's section, the *impulses* passing through the condenser. The lamp in the calling-cord circuit will light when the operator connects with the subcriber, and will remain alight, except during the ringing periods, until the subscriber responds. When he does so, it darkens, and the operator leaves the key in the normal, or through position, knowing from the fact that both lamps are dark that both the subscribers are at their instruments.

Clear Signal. On finishing their talk, the subscribers hang up their receivers, and both line circuits are opened at the automatic switches. The cord-circuit relays are thus de-energised, their armatures fall back and open the shunt circuit, thus allowing the cord lamps to glow.

Metering the Call. Immediately before withdrawing the plugs the operator depresses the "meter key." This records the call on the meter of the subscriber with whose line the answering plug is in connection. It simultaneously counts one on the operator's position meter and lights a red lamp in front of the operator, to indicate that its functions have been correctly performed.

In order to avoid complication, the meter circuit has been omitted from the diagram. It will, however, be sufficient to explain that each subscriber's meter is joined in parallel with the cut-off relay. The meter, therefore, receives current from the 24-volt battery when the cut-off relay is energised; but its resistance is 500 ohms, and it is not affected



15 SWITCH SECTION—THREE "A" POSITIONS

thereby. When the operator depresses the meter key she connects a 30-volt battery to the sleeve of the plug, and this sends a current which is strong enough to effect the desired result. The meter is merely a Veeder cyclometer mechanism actuated by a specially designed electromagnet

Continuous Insulation Test. One very annoying feature of the magneto system was that faults were discovered only when an effort was made to bring the circuit into use. On the central energy system faults due to breakdown of the insulation announce themselves immediately they appear, and are removed in many cases without the subscriber knowing anything about them. An earth fault on the A line causes the line relay to be energised, and therefore gives a permanent glow on the calling lamp until cleared. Contact from line to line has a similar effect. To provide for faults on the B, or "power" line, special lamps are provided. These are not in the switch-room. As they are provided purely for this "test," they are put in the "apparatus" room along with the relays and meters, where they are under the constant observation of the engineering staff.

16. SUBSCRIBERS' CALLING-LAMP

17. SUBSCRIBERS' ANSWERING JACK

18. THREE-CONDUCTOR PLUG

Subscribers' Induction Coil. The induction coil at the subscriber's station, although not absolutely essential, serves two useful purposes. It allows the receiver to be removed from the main circuit, and thus kept free from the effects of the heavy current. It also enables the condenser to be brought into use for enhancing the effect of the transmitter. Every variation in the resistance of the transmitter varies the difference of potential at the transmitter terminals, and is therefore accompanied by a series of rapid charges and discharges. These pass through the receiver and one winding of the induction coil, and the latter by mutual induction affects the winding in the main circuit so as to supplement the effect of the transmitter.

Detailed Description of a Switch Section. A switch section [15] is arranged to accommodate three operators. One complete section of the multiple spreads across the upper section of the board, and is distributed within nine vertical panels. The method of numbering is a little peculiar at first sight, due to the fact that it begins from 0 instead of from 1. The first hundred jacks are therefore numbered 0 to 99, and are known as the "nought hundred." The next 100 is from 101 to 199, referred to as the "one hundred."

19. CORD WITH STEEL CONDUCTORS

It will be seen that the introduction of this insignificant cipher results in all the numbers in a given block commencing with the same figure. The jacks are arranged in strips of twenty. At the bottom left-hand corner of the multiple the "nought hundred" can be observed. Within the limits of each hundred the numbers read in the same way as in a book—left to right, and downwards. The blocks of hundreds, however, read from left to right and upwards, this arrangement being necessary from the fact that the multiple is only built up from time to time as the growth of the exchange demands. A 9-panel multiple has for some time been the standard, the jacks being spaced ⅜ in. apart from centre to centre. Some makers have advocated a 10-panel multiple, which would have the advantage of putting the hundred blocks in proper decimal order. Immediately below the subscribers' multiple panels, and separated therefrom by several blank panels, there is a second multiple, known as the "junction multiple." It contains the jacks connected to the lines to other exchanges, and these are multiplied once every six panels. The letters on the white label strips above them are the codes of the respective exchanges. Beneath the junction multiple in the centre of each operator's position there is another strip of 20 jacks, which is used for "busy-back" connections and record circuits, the latter being circuits to the trunk exchange, by means of which subscribers can dictate their wishes to the trunk record operator when they require a trunk call. The lower panels contain the subscribers' calling-lamps [16], and above each the corresponding answering jack [17]. The answering lamps are numbered in regular numerical order from left to right and upwards. These are subscribers' *position* numbers, and do not change. The answering jacks, however, may be connected to any particular subscriber, and a figure plate on the right of the jack gives the number of the connected subscriber.

It will be noted that the operator requires to take no cognisance of this number. If the lamp lights, it is necessary for her only to plug into the jack above it, and carry out the wishes of the subscriber who speaks. The three panels which constitute an operator's position are provided with a number of answering jacks and lamps in accordance with the character of the exchange. If it is a very busy one, the number may be as low as 80; if, on the other hand, it is a residential exchange with message-rate subscribers, the number may go up, as in this case, to 180, each of the panels having 60 lamps.

Beneath each block of 60 answering lamps there is a large white lamp, known as the "pilot lamp." When any one of the 60 subscribers calls, the pilot lamp in a given panel lights up at the same time as the answering lamp. In the centre panel there are, in addition to the pilot lamp, two other large lamps, one red and the other green. The red one is the "meter lamp," of which more anon, and the green one, the "instruction lamp." The last-named is in connection with the supervisor's desk, and by its means the supervisor can attract the attention of

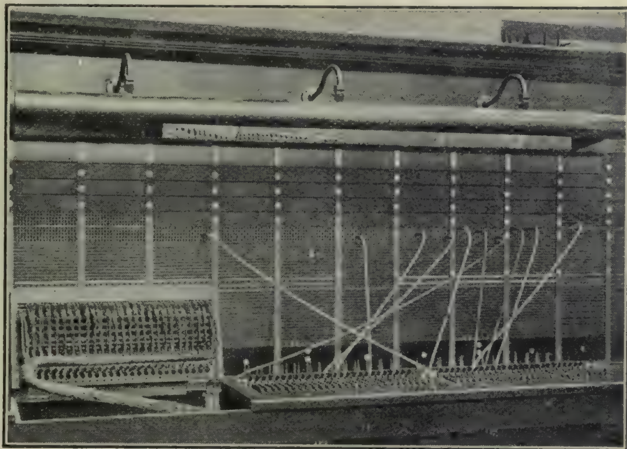
any one or all of the operators, and transmit to them any required information.

This disposes of the vertical part of the switch section, and we shall now deal with the keyboard, which projects in front of the operator to a distance of 15 in.

Beginning from the rear, we have a line of 17 answering plugs [18]; and next, a line of 17 calling plugs, each of these being, of course, paired off with an answering plug. Vari-coloured cords [19] are used; the first pair may have red cords, the second blue, the third green, and so on. This use of colours facilitates the identification of cords when a connection is being taken down. In front of the calling plugs there are 17 meter keys; then two rows, each containing 17 supervisory lamps, the rear row for the answering cords, and the front row for the calling cords.

The next rank, and the one furthest forward, consists of 17 combined listening and ringing keys, and in line with these on the extreme right there is an 18th key, which is used for ringing on "call wires" at night.

To the left of the operator's position can be seen a number of small buttons, resembling the keys of an English concertina. These are variously known as "order wire keys," or "call wire keys," these being the American and English synonymous titles.


20. JUNCTION SECTION—THREE "B" POSITIONS

Junction Sections. Sections of the kind just described are known as "subscribers' operators' sections," to distinguish them from junction sections [20], or the same distinction is effected by referring to the subscribers' answering position as the A position, the incoming junction section being called the B position.

In large telephone areas, such as London and New York, where the proportion of inter-exchange traffic may be 80 per cent. to 90 per cent., the junction traffic becomes exceedingly important, and at a given exchange the number of B operators may be equal to half of the A operators, in spite of the fact that arrangements are made which allow of the B operator dealing with a relatively larger number of transactions. Fig. 20 shows a typical B section. Like the A section it provides positions for three operators. As there are no subscribers' lamps, the multiple begins lower down, the subscribers' multiple and junction multiple together occupying the whole of the vertical space.

The incoming ends of all junctions terminate in plugs. In front of each plug there is a corresponding signal-lamp, and in line with this a listening key, and what is known as a "machine ringing key," from the fact that when once depressed to call a subscriber it remains actuated until the subscriber replies, when it is automatically released. The headgear of the B operator is permanently connected to the call wire, or call wires, coming from the exchange or exchanges from which come her set of junctions. The B operator usually controls 26 junctions.

A Through Call. Now let us describe a transaction passing through two exchanges. The subscriber calls the A operator, she inserts the answering plug, turning over the listening key and replies. The subscriber asks for B Exchange No. 369. The operator immediately depresses the B exchange call-wire key, and says to the B operator "369 A." The B operator being thus informed of the number required and the exchange making the request, observes which of the junctions from A are not in use by looking at the plugs and names one of them, say 15. The A operator immediately connects to the number 15 B junction, the operator turns No. 15 ringing key, lifts the plug, and tests the required subscriber. If no click is heard, she presses forward the plug and depresses the No. 15 ringing key. If, however, the subscriber is engaged, the B operator connects the plug to one of the "busy-back" jacks. This has the effect of sending back on the junction line to the calling subscriber an intermittent buzz, which means "line engaged." The lamps in circuit give flashing signals until the calling subscriber accepts the intimation, and restores his telephone, when the lamps give the ordinary signals described later.

Calling currents will circulate from the generator at the B exchange continuously until the subscriber answers, and the B operator is required only to keep an eye on the ringing key, which automatically restores, as before stated, when the subscriber lifts his receiver to reply.

At the conclusion of the conversation, when the subscribers restore their receivers, the two lamps at the A exchange are actuated. The A operator depresses the meter key and disconnects. Immediately she does so the lamp at B lights, indicating that the junction may be cleared, and the B operator takes down the connections.

It will be seen that a B operator has but little to do, and she can accordingly deal with more transactions per hour, the recognised average for a good B operator being 300 calls.

Continued

CLOCK REPAIRING

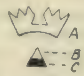
Repairing Clock Teeth. Escape Wheels and Pallets. Pivot Holes and Rack Tails. French and other Clocks

BY JOHN P. LORD

For most ordinary clocks, wheels can be purchased in sets; for special ones you will have to order them from the wheel-cutter, for making wheels is a separate trade of itself, and should be classed under turning. There is a popular idea that the teeth of American wheels are punched or stamped out. This is erroneous, for they are cut some fifty at a time by a saw-like grooving machine, and so are produced cheaply; English wheels are cut on a special lathe with a "fly cutter." The teeth of wheels when bought are generally finished, save for an occasional burr which may require filing out, and, perhaps, if a new wheel has to go into an old and much worn clock the teeth may require a little more topping. As a rule, however, the wheels are not quite finished and ready for use, for they must either have the spaces cut out and the crossings actually made, or those already there will be so rough as to require a good deal of filing and rough polishing to make them neat and workmanlike. When the crossing out is done the wheels can be mounted on their collets and arbors, and then polished, if sufficiently rigid, by holding a polisher charged with emery and oil, followed by crocus and oil, against the revolving surface, or, if fragile, by laying them on a large, flat cork and polishing thus, the wheel being slowly turned by the hand the while.

The wheels, as we have seen, are riveted on to collets, which are soldered on to the pinion arbors, and the riveting must be very carefully done with a round punch or a half round one.

To Repair a Broken Tooth. This is a job which occasionally faces the clockmaker, and ability to do so neatly will save you using many new wheels and wasting a great deal of time. In the solid rim of the wheel, at the space vacated by the broken tooth, saw out a dovetail-shaped hole in the brass. From a sheet of brass, a little thicker than the brass of the wheel, cut an oblong piece of brass, with a dovetail at one end a very little larger than the hole in the wheel. Now measure this little bit and cut off the surplus of the oblong, leaving a little more than enough to form the new tooth. All this cutting can be done with a bow saw, such as is used by metal-workers, remembering that the teeth of the saw must be made to point backwards, so as to cut with the draw and not with the thrust. File your dovetail exactly to fit the hole, and then chamfer off a little from the sharp edges of the hole. Now put in your piece of brass and carefully rivet it into place with a very light hammer. If the wheel is very fragile, then you will have to run a little tinning fluid on the edge of the piece before you put it in, give one or two taps with the hammer, so as to just make a slight rivet, and run a little solder round the join which will find its way in sufficiently to make a firm joint. In all riveting the greatest care must be taken not to spread the wheel in the least, and it is as well to practise on one or two old wheels before actually operating on a good one.



4. INSERTING NEW TOOTH
A. Broken wheel, with dovetail cut *B*. New tooth *C*. New portion of wheel

As soon as the riveting is done, or the solder set, shape the projecting brass to resemble the other teeth exactly, using a topping file so as not to injure the adjacent teeth. Then file and polish both sides of the wheel where the join is so as to make the new piece flush with the original wheel, and if this is well done the join will be almost imperceptible.

Should several adjacent teeth be missing, as sometimes happens when a clock has violently run down and a portion of a wheel been stripped, or when children have dropped an object into the works, you must either put in a new wheel, or, if that is not convenient, you must make a dovetail with a curved base in the rim and fit a piece of brass as before. Then another method must be employed to plot out the new teeth which have to be cut. Take a piece of zinc large enough to cover several teeth on each side of the break, and bore a hole in it. Fit it tightly to the arbor or pinion, and turn it round so as to embrace a curve of sound teeth. Now cut it circular along the rim, and with a fine saw cut out a set of teeth in the zinc embracing *at least two on either side of the number of missing teeth.* Finish these teeth off with a file till they are exact replicas of the wheel teeth. If this plate is now turned round on the arbor till the last two teeth on each side exactly coincide with the two sound teeth on each side of the break, a whole range of new teeth can be cut most rapidly in the piece of brass inserted. This is a simple and masterly way of overcoming the difficulty, and its inventor deserves much praise.

Before placing any wheel in a clock it must be tested to see if it runs true and is flat, as was done when we examined our clock, and if out of true must be adjusted.

The Escape Wheel. These wheels are the bugbear of the clockmaker, for they are difficult to repair, makers each having their own standard for the making of the pallets to fit them, and though theory says one thing, the manufacturers still hold to the rule of thumb which their escape-makers employ. In many cases the escape wheel can be made serviceable by putting it into a lathe or on an arbor in the turns and topping each tooth with a fine file till all the teeth are of equal length, and then filing up each tooth to the original shape. A hint that may be useful in doing this is to top all but *one* tooth, and use that tooth as a pattern in dressing the others, and lastly to dress that one to resemble its fellows. After this operation the depthing of the pallets will have to be altered. If, however, the spacing between the teeth of the escape wheel is uneven, throw the wheel away, buy a new one, and make new pallets to fit it.

The Pallets. These are the first parts of the clock to wear out, as might be expected, since they have more work to do than any other portion. They can sometimes be repaired, if recoil pallets,

in the following manner. First let down the temper of the hard steel by heating the pallets a cherry red, after they have been removed from their arbor. Let them cool gradually. Then a file will bite them well, and they can be filed to shape, first filing out the worn marks, and then bending the soft steel into proper shape to avoid wasting more metal than is absolutely necessary. Next smooth and polish up the acting faces in the ordinary manner. The pallets must then be bent to embrace the number of teeth that they originally did, for the filing will have widened the space between them, and this is best done by very gentle squeezing in the jaws of the vice, squeezing in half the distance first, and then reversing the pallets and squeezing in the other half. Now they must be tried in the frame and the proper depthing arranged for. If it is not much it can be effected by lowering the cock a little. If you have to bend the pallets more than once you must heat and allow to get cool before each bending or the steel will snap. When the drop and escapement is satisfactory heat the pallets a cherry red and plunge into cold water; then brighten a portion with emery and heat again till that portion becomes a straw yellow; after which allow them to cool. New pallets must be made in the same way from soft steel, or steel which has been let down, filed out to shape, made to fit and work, and then tempered. The old pallet will serve as a model.

Collets. These are short brass or steel cylinders or bosses which fit on arbors. Those for the reception of small wheels are made out of brass and turned on an arbor in the turns. An arbor for this work is a grooved, slightly tapering piece of steel with a fixed ferrule for the bow string, and with pivots at each end to run accurately between two female centres on the turn. They are very useful for truing wheels and other work where a perfect centre arbor is required. Collets for the hands are known as *split collets*, because they have a slit in them just as long as the collet is wide.

New Pivot Holes. It often happens that in the adjusting of a clock or the setting up of a new one that the pivot holes in the plates are unsuitable. When this is the case new holes have to be made. This is the ordinary method of doing the work.

Ascertain the direction of the principal wear in the old pivot hole, and then with a broach, which is a four or five-edged steel tapering cutting tool, something like a leather punch, enlarge the hole, first filing the unworn parts till they are equal to the worn parts with a round file. The hole should be made three times as large as it was before. Now take a piece of brass thicker than the plate and drill a hole in it smaller than the pivot requires. Mount this on an arbor and turn till it accurately fits the hole. Chamfer the edges of the hole slightly, and rivet in the new piece. File it level with its plates and polish off. Then gradually enlarge the hole till it just takes the pivot, and countersink the outside edge to hold the oil. This operation can be very speedily performed after a little practice and will give much better results than attempting to close the enlarged hole.

When a raised bush is required, as is the case when the action on the pinions has to be shifted, the piece of brass put in as a bush must be a good deal thicker than the plate, riveted level on the outer side, and filed down to the right thickness on the inner face. This expedient will save many a clock.

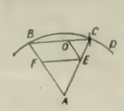
Eccentric Bushes. Should you desire to make a new pivot hole, and are not quite certain about the depthing of the wheel, but would like to have a little latitude, which will enable you to adjust it after you have put in the bush, there are two methods of doing this. If you have a lathe with a chuck which will hold a stout piece of brass wire, select a piece which is a good deal larger than the hole which you have broached in the plate, which in this case should be four times as large as the original pivot hole. Turn the wire to fit the hole, and then with a tap of the hammer set it just as much out of truth as you wish the pivot hole to be eccentric. In this new position centre the flat end of the wire and bore a small hole, not quite so large as the pivot.

Next see that the hole in the plate is nicely chamfered, and is slightly wider on the outside than on the in. Cut off the wire a very little thicker than the thickness of the plate, and enlarge the pivot hole with a broach just to hold its pivot. Then fit in the bush and the pivot, and you will be able to turn the eccentric bush round in its hole till the depthing of the wheel is exactly right. A few taps with the hammer will then close the riveting and hold the bush firmly in its place. If necessary, the slightly projecting portion may be filed down, but after a little practice the right amount will be easily estimated, and the riveting will make all flat enough to polish. The pivot hole must now be again enlarged to permit the pivot to turn freely, and then polished with a smooth, circular broach. Making countersinks for the oil completes this job.

If you wish to make an eccentric bush without a lathe and only with the turns, you will have to make a bush in the ordinary way on the arbor, then plug the central hole and drill a fresh one a little out of the true centre. This is unsatisfactory, and under such circumstances the following will be the best course to pursue. Broach out the old hole to an irregular shape to prevent the new plug from turning. Fit a plug filed to fit it exactly and rivet it in its place with a round-faced hammer. File down and polish. Now try the depth and where the point of the pivot rests; when the depthing is right, make a mark, and there drill a new pivot hole, afterwards countersinking the oil-hole.

Rack Tails. Frequently in a striking clock the rack tail will be found to be at fault, and this is easily tested by allowing the rack to fall till the tail rests on the lowest step of the snail. The rack hook should then hold the rack in such a position that there are twelve teeth to be gathered up. If the rack tail be now placed on the highest step, the rack tooth should rest in the first tooth space, leaving only one tooth to be picked up. If these conditions are not fulfilled the rack tail is wrong, and as it probably is faultily made, it is as well to know how to calculate the length of a new one.

With a pair of compasses measure the distance from the centre of the stud upon which the rack turns to the points of the rack teeth. Call this AB, and strike an arc of a circle with centre A and distance AB. Call this arc BCD. Again measure the distance the rack teeth fall for twelve to be struck, and with this for radius and B for centre, describe an arc cutting BCD at C. Join AC and BC. Take the total distance the rack tail has to fall, from the highest step to the lowest of the snail, and call this BO. Measure this distance from B along



5. DIAGRAM TO CUT RACK TAIL

BC. BO is the distance. Through O draw a line OE parallel to BA and cutting AC at E. Through E draw a line parallel to BC cutting AB at F. EF is the length of the new rack tail, which can then be made on the model of the old one as to shape.

Plates and Pillars for New Clocks. If you wish to make a new clock, you had best first purchase your train of wheels according to the beat of the pendulum which you intend to use. Carefully measuring the exact size of these wheels with your callipers, set them out on a piece of paper the size of the plates, or the approximate size thereof, beginning with the centre wheel. Remember the depthing, and allow the teeth to engage two-thirds of their depth, which means that for measurements you must take off one-third of the depth of the teeth of each wheel to get its centre. Following on on this plan, map out on your paper the exact positions of the centres of each pivot, doing your best to get the escapement in the centre line at the top.

When this is done take two pieces of hard brass of the requisite size and file and face them up till they are perfectly true. Then polish them to a fair polish. Now pin these two together with two or three small pins close to the edges of the plates. On one of them copy your plan, setting out the positions of the pivot holes. The plates are now placed under a vertical drilling machine and holes drilled through both plates at the same time. Clean out the holes.

Pillars in the rough can be bought for the frame, and these must be filed and polished up. Pin-points and holes for the pins must be made at one end of each, and at the other rivet bosses. The pillars are then riveted into holes made in the back plate, and the shoulders of the pin points will fit into the holes made for them in the upper plate if the holes were all drilled at the same time while the plates were fixed together. By this method the clock case is made perfectly true and square. The wheels will then have to be fitted, each one to its own pivot holes, which may have to be slightly enlarged, and will certainly have to be polished with a round broach and chamfered on the outside face. The treatment of the wheels and pinions will be precisely the same as the fitting of a new wheel and pinion described under Repairs. Studs to hold the minute wheel and other portions of the mechanism will have to be riveted into their places according to the plan; but this is really mere practical mechanics, and not horology. If the foregoing pages have been digested and the practical work studiously followed, there should be little difficulty in making the clock go well.

Other Forms of Clocks. One of the most delicate forms of clocks which are to be found all over the world are the French clocks. They are usually to be found in marble cases or under glass shades, and in many unimportant particulars they differ from the British clock to which we are now accustomed. The mechanism of French clocks is small, and might almost be called large watch work, so slender are the pinions and so fragile the wheels. The typical French clock has the following wheels in the going train—great wheel turned by a spring in a drum exactly like a watch spring, which we shall shortly describe, a centre wheel and pinion, a third wheel, and a 'scape pinion and wheel. The escapement is usually of the dead-beat type, but in the case of drum French clocks the escape is a recoil. They have very short pendulums, with a relatively heavy bob. The pallets and the 'scape wheel are very often on the dial of the clock, and then are gilt; this entails the pinion, on a very long arbor, being within the frame, and the 'scape wheel on the end of a prolonged pivot. Often a second blank wheel is found on the 'scape arbor within the clock to ensure steadiness.

The crutch is short, and passes through the projecting part of the pendulum rod, which has a slit in it instead of a fork. The suspension spring often has what is called a regulator Brocot, which operates on the pendulum spring itself by being slid up or down, thus shortening the effective length of the pendulum.

The striking parts of French clocks are all marked, so no possible mistake can occur in putting them together. The old ones have not a snail like our clocks, but a locking plate instead, which works in the reverse manner, otherwise they are very much the same, and a few minutes' inspection will explain their action better than pages of description.

Turret Clocks. These enormous clocks, used for church towers and for large public buildings, are the work of a special class of clockmaker. The theory upon which they are built is the same as that of our regulator clocks, but, of course, their massive character makes it necessary to keep as many wheels along a horizontal line as possible. Moreover, each wheel has to be capable of being removed from the frame without disturbing the rest of the clock, so all run in bushes instead of pivot holes.

They are fitted with heavy pendulums. The great length of the hands, which in winter may be loaded with snow and are often accelerated or retarded by strong winds, makes special forms of escapement desirable. The 'scape wheel to which we have grown familiar is sometimes replaced by four or six legged stars. The best have detached pallets; that is to say, that each pallet is on a hinge by itself, and is weighted so that it returns to its place by its own weight and at the same time imparts an impulse to the pendulum. Owing to the long time which they take to wind, some special arrangement has to be made to keep the clock going while the heavy weights are being slowly wound up. This arrangement is known as a maintaining power, which, by means of a spring, or of additional weights, keeps the great wheel turning quite independent of the main weights for a short time. The main weights then act again for a second or two, returning the maintaining power, too, in its place, and immediately that again begins to act, and so the clock keeps going without a stop. The mechanism is complex, and not likely to come within the scope of the ordinary watchmaker, and certainly not of the beginner.

The theory and designing of these clocks is the work of advanced scientists, and the construction forms a part of very heavy and accurate mechanical engineering.

Continued

ORCHESTRAS AND CHOIRS

Orchestration—continued. Instruments in Combination. The String Band. The Full Orchestra and Theatre Band. Conducting and Choir Training

Group 22
MUSIC
41

Continued from page 5734

By PAUL CORDER

HAVING briefly described the instruments most generally in use in the modern orchestra, we may now consider the effect of them in combination.

The String Band. First in importance comes that group known as the string quartet, or string band. As has been already mentioned, this consists of a number of violins divided into firsts and seconds, a smaller number of violas, violoncellos, and double-basses. The relative numbers of these constituents vary considerably, but an ideal orchestra might contain 16 first violins, 16 second violins, 12 violas, 12 'cellos, 8 basses.

The beginner will perhaps be disposed to think that there is not much variety to be obtained from this one type of instrument, but a slight investigation of already existing music will speedily convince him to the contrary. Let us cull four examples at random, and note the immense contrasts of colour [Ex. **46–49**].

In our first example, from Mendelssohn's overture to the "Midsummer Night's Dream," an effect of ethereal lightness is produced by the *pianissimo staccato* of the violins; the 'cello and bass, too heavy for this fairy music, are omitted altogether. Attention should be drawn to the fact that both the first and second violins are divided—that is, the violins are playing in four parts instead of two. This is a most valuable device in orchestral writing, and many composers have still further elaborated it by dividing certain sections of the strings into four, eight, twelve, or even sixteen parts; but it is doubtful whether the effect in performance justifies the labour entailed in the writing.

The device of dividing the 'cellos into four parts may be seen in our second example; the effect in performance is one of the most beautiful in the whole range of orchestration. In the third example is shown a solo for the violas and 'cellos in unison, with the basses accompanying pizzicato. Lastly, the strings are shown in a polyphonic movement—a word meaning, literally, many-sounding, but used synonymously with contrapuntal.

This is but a small selection of the different effects that can be produced by the strings alone. Before proceeding further, the student is recommended to take a selection of simple piano pieces and score them for string orchestra. The following suggestions may be helpful:

Beethoven. Sonata Op. 2, No. 2. (Slow movement.)

Beethoven. Moonlight Sonata. (2nd movement.)

Schumann. Papillons. Op. 2. Nos. 1, 3, 4, 5, 8, 12.

Schumann. Kinderscenen. (A selection)

Grieg. Lyric Pieces. (A suitable selection)

Schubert. Theme from Impromptu in B♭.

Rubinstein. Melody in F.

Chopin. Several of the Mazurkas.

A few remarks on the transcribing of pianoforte music for the orchestra will not be out of place at this point. Most young composers, from long acquaintance with the instrument, have acquired the habit of considering pianoforte music as the standard, and when they first attempt to write for the orchestra in nine cases out of ten they write first for the piano and then translate, as it were, their music into the orchestral idiom. This is a very natural procedure, and a by no means harmful one, provided a literal translation is not attempted, but the peculiarities of the orchestra kept in mind from the beginning. For instance, the number and position of the notes in a chord are limited, on the piano, by the fingers of the performer. Not so in the orchestra, where the performers are numerous. Thus the final chords of a piano piece may be illustrated as in Ex. **50**. The top and bottom consist of a full chord, and the ear has accustomed itself to imagine the middle part to be filled in. But if we try this on the orchestra the gap in the middle would be painfully obvious; moreover, the thick harmony low down would be quite indistinguishable. It may be laid down as a rough rule that in a chord the parts should be tolerably evenly distributed; a larger gap is advisable low down (between the bass and the middle) than higher up. The natural series of harmonics given in Ex. **29** [page 5731] affords a good example of this treatment. So that our two chords should be scored as shown in Ex. **51**.

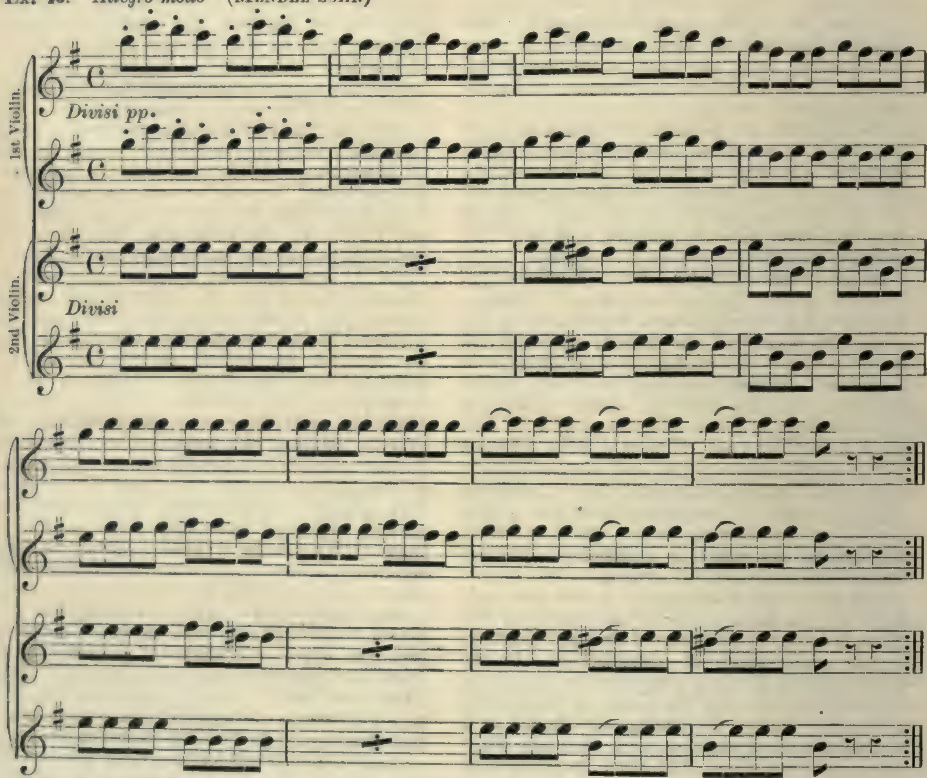
Acciaccaturas and Arpeggios. A device frequently met with in piano music to give the effect of widespread harmony is to write the bass note as an acciaccatura [**52**]. These notes are, of course, intended to be sustained by means of the pedal, and so the passage just given would be scored as shown in Ex. **53**.

Another prominent feature of the piano is the ease with which extended arpeggios are played. There is no analogy to this in the orchestra, except on the harp. But the tone of this is so weak in comparison with the other instruments that it is hardly advisable to transcribe a pianoforte accompaniment as it stands for the harp. Some other means must therefore be sought for when translating this familiar feature.

Let us take a rather extreme instance. Chopin, one of the most pianistic of all composers, will furnish us with plenty. We select at random the Study in F major in the second book of Op. 10 [**54**]. The inexperienced student might think it possible to score this as it stands [**55**], but he

may be assured that the effect would be anything but pleasing; a passage so pianistic requires entirely remodelling to fit it for stringed instruments. In passing, however, attention should be drawn to the fact that when it is necessary to distribute a passage among different instruments, in order to avoid a " break " at the joins it is advisable to make the parts overlap—that is, to let the new part be taken up before the previous one ends [**59**]. However, even if this were done in the present instance the passage would still be uncomfortable, and to obtain the best result we must rearrange it, taking advantage of our knowledge of the violin family to make it lie well for the instruments. The translation given bears a considerable resemblance to the original,

Ex. 46. *Allegro molto* (Mendelssohn)



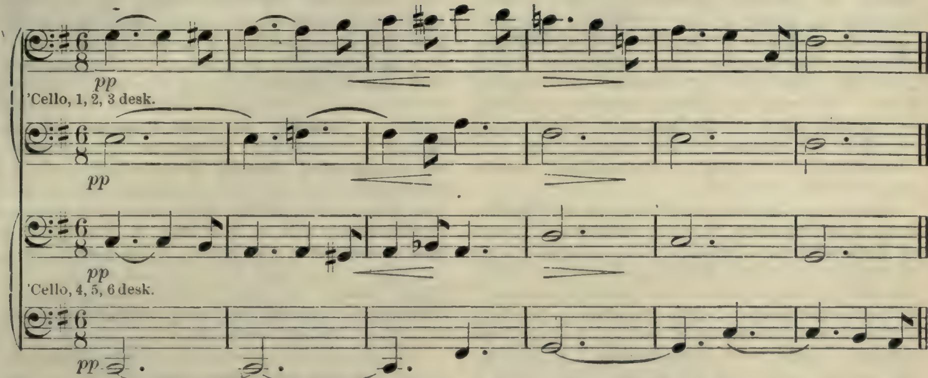
and is not at all difficult to play. In crossing the strings every use is made of the open notes [**56**]. But this is not the only possible version. Here is another even easier, though less closely resembling the original [**57**]. A few typical passages may here be given with a suggestion for their treatment, the device of double-bowed notes proving exceedingly useful [**58**, **60**, and **61**].

The Full Orchestra. The term " full orchestra " is used to denote the collection of instruments generally found at the principal London concerts, and for which modern composers are accustomed to write. It consists essentially of a fairly large and tolerably well balanced body of strings; wood-wind represented by two flutes, two oboes, two clarionets, two bassoons, with the addition, ad libitum, of a piccolo, cor anglais, bass clarionet, and double bassoon, and, on occasion, even further reinforcements; four horns (occasionally six or eight; these instruments are always employed in pairs), two or three trumpets, two tenor and one bass trombone, one tuba (these last forming a quartet of brass), two or three timpani, and other percussion instruments at the pleasure of the composer. A harp is a not infrequent addition.

The beginner will feel at a loss to know how to dispose of this great mass of instruments, but let him reflect that it is not at all necessary for all of them to play at once. In his first attempts at scoring he will do better to err on the side of thinness than the reverse, to which end he should start by writing for small orchestra, or, better still, for theatre band. Let him consider the wood-wind as the solo stops, as it were, of an organ, impressing his mind early with the precise tone-colour of each instrument.

It will be as well if, at this point, we consider the wood-wind apart from the rest of the orchestra, and afterwards endeavour to combine them with the strings. And, first, as to the tone-colour of each separate constituent. Can anyone who

Ex. 47 (Wagner—"Siegfried")



has heard Dvorâk's New World Symphony forget the luscious effect of the flute low down in the phrase [62]? A typical instance of the higher register of this instrument may be found at the beginning of the second act of "Carmen," where two flutes play [63]. Owing to the flute's excessive delicacy the greatest care is necessary in accompanying a solo; strings should be almost invariably employed for the purpose. It may be stated, as a rule, that when a wind instrument has a melody, another instrument of the same kind should not be in use. This does not apply to the example above, where the two flutes in thirds form the essential feature of the melody.

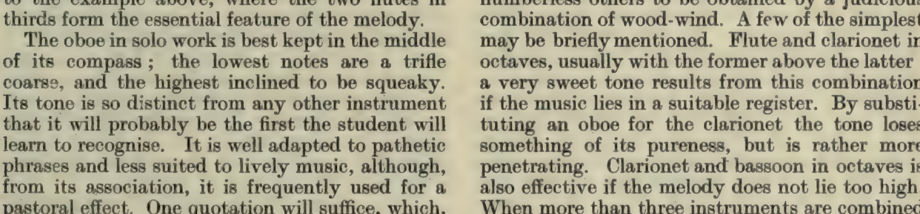
The oboe in solo work is best kept in the middle of its compass; the lowest notes are a trifle coarse, and the highest inclined to be squeaky. Its tone is so distinct from any other instrument that it will probably be the first the student will learn to recognise. It is well adapted to pathetic phrases and less suited to lively music, although, from its association, it is frequently used for a pastoral effect. One quotation will suffice, which, although rather high, is effective [64].

The clarionet is, perhaps, the most useful of all the wood-wind, partly on account of its extensive compass. Its tone-colour in the higher register differs considerably from that of its lowest octave, consequently it is possible to make an exception to the rule given above and allow a melody on one clarionet to be accompanied on another. The clarionet seems to have been Weber's favourite instrument, and a glance at almost any of his scores will reveal many beautiful and characteristic instances of its use. For solo use in the orchestra the bassoon has commanded less attention than it deserves; it has great expression of pathos on its higher notes, though florid passages low down invariably sound grotesque and comic. Beethoven, who treated all instruments with loving partiality, has left us some charming specimens of bassoon writing. Note the contrast between the mournful solo in the Rondo of the Violin Concerto [65] and a passage from the Fourth Symphony [66].

Besides these "primary colours" there are numberless others to be obtained by a judicious combination of wood-wind. A few of the simplest may be briefly mentioned. Flute and clarionet in octaves, usually with the former above the latter; a very sweet tone results from this combination if the music lies in a suitable register. By substituting an oboe for the clarionet the tone loses something of its pureness, but is rather more penetrating. Clarionet and bassoon in octaves is also effective if the melody does not lie too high. When more than three instruments are combined on one part the tone-colour loses distinction but gains in intensity, and additional instruments make but little difference except in tone-quality.

Although not strictly of the wood-wind class, the horn bears a decided resemblance to those, inasmuch as it combines beautifully with them and, furthermore, has valuable properties as a solo instrument. Its soft, dreamy tone in *piano* is unapproachable. In addition to this its tone in a *forte* is quite "brassy"; a passage for horns such as that shown in Ex. 67 has

Ex. 48. *Andante* (Beethoven)



almost the effect of trombones. Since there are four of them in the orchestra, four-part harmony on horns is possible and exceedingly effective. Considerable use is made of them, moreover (especially by German and modern British writers), for filling in and sustaining the middle parts of the harmony, which gives an effect of fulness to the music; but this should not be indulged in to excess, as it results in monotony of colour.

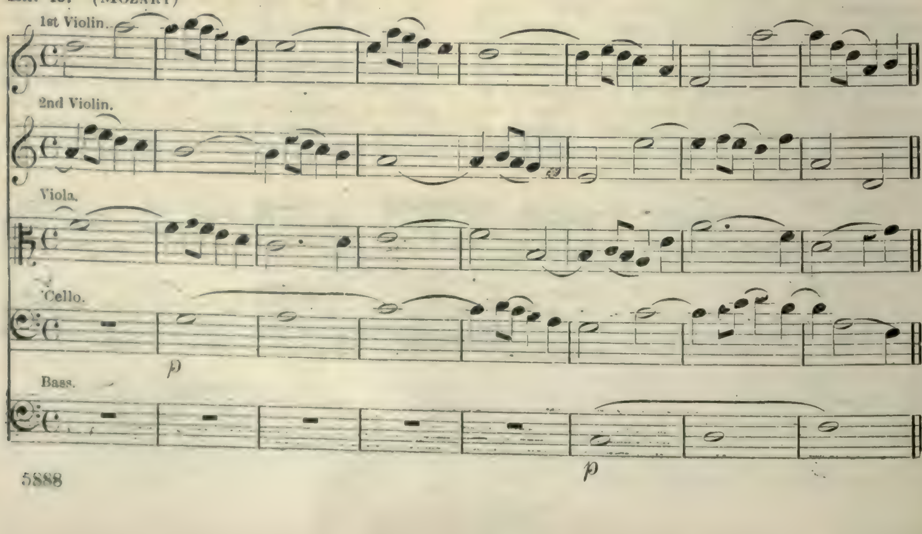
Now let us combine our forces, and add thereto a couple of trumpets, three trombones, and a pair of kettle-drums (timpani). This brings before us another question, balance of tone—that is, the different degrees of sound intensity possessed by each instrument. Until we know something of this it will be impossible to say, in any given passage, what will predominate. Normally, the highest part will stand out more than a middle one or the bass. But the matter is more complex than this. Score a few bars suitably for full orchestra, mark each part off, and what is the result? You will hear the trumpets, trombones, and drums; if the violins are written high up you may hear them to some extent. The wood-wind are inaudible.

Having learned from this which instruments can play the loudest, let us inquire which are best able to play *pp*. The honours are fairly divided here, but again the timpani may be considered to hold first place with an almost inaudible roll, followed closely by the strings, horns, and the low notes of the clarinet and flute. With these two exceptions the wood-wind are least able to play *pp*; that is, they have the smallest range of tone of any save the harp. This latter instrument is the first to be swamped by horns and wood-wind, and must be written high up if it is to be heard at all. In a *forte* without brass the strings have it all their own way, unless the wind are massed together high up, and even then the balance will not be good. In a passage from Beethoven's Fifth Symphony [68] it is probable that the imitation on the wood-wind has never been heard; if it has the conductor was responsible, not Beethoven. The weakness of the wood-wind when played against the strings *forte* has been insisted on at some length, as it is a fact invariably overlooked by the beginner, and his disappointment at finding a choice counter-subject rendered inaudible from this cause is generally the best reminder of the futility of his scoring. He is then apt to acquire an exaggerated idea of the weakness of the wind, and if he scores a pianissimo melody for, say, a solo 'cello with a light wood-wind accompaniment he will be horrified at the loudness and coarseness of the latter. This merely bears out what was said of the smallness of the wood-wind's range of tone. When anything like delicacy is wanted for an accompaniment the strings are unapproachable.

We are now in a position to score some simple pieces for full orchestra. The Menuetto from Grieg's Piano Sonata in E minor will be easy and effective for a first attempt. The opening might be given to the strings—it must be remembered that it is not necessary to lay out the harmony in "handfuls" when dealing with the orchestra; at the *fortissimo* the tone should be reinforced by the addition of the wind and brass, keeping the wood-wind high up and the brass nicely laid out over the harmony, the violins, perhaps, in octaves on the melody. At the double-bar the melody in thirds would fit two clarionets, accompanied by strings. The accents on the second beat might be reinforced with other instruments. The trio will afford a good opportunity for the wind and strings to be used antiphonally. Score the first eight bars for wood-wind alone; the flute had better have the top part, and the bassoons may be omitted or not, at pleasure. The succeeding eight bars should be strings alone. At the return of the minuet it would be well to vary the treatment somewhat, for the sake of variety.

Other pieces suitable for full orchestra will readily occur to the student. Beethoven's Funeral March from the Sonata Op. 26 offers good scope, Schumann's Carnival (a selection).

Ex. 49. (MOZART)



many of Schubert's marches, and Dvorâk's "Bohmer Wald" piano duets, although more difficult, would be very effective.

Before we can make any progress in modern orchestration it is, above all things, essential to the student to hear his work performed, however badly; and at that performance let him listen with all his intelligence alert, analysing every sound and comparing it with what his imagination had depicted. He will learn more from hearing and comprehending his errors than from pages of written instructions, provided he has acquired the groundwork, the technique, as it were, of orchestration. Much can be done from the study of scores, but only those he has heard and well remembers the effect of in performance. It will take years of experience before he can realise the sound of a score he has never heard.

Ex. 50.

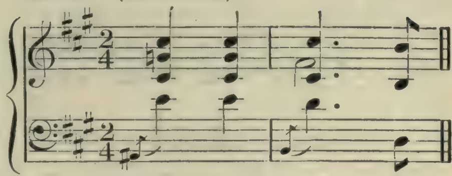
Ex. 51.

We can but briefly refer to the other varieties of orchestra previously enumerated.

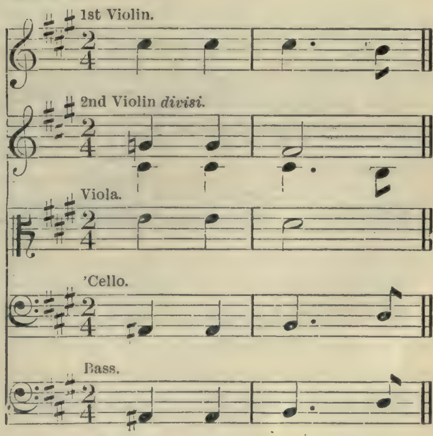
The Small Orchestra. The small orchestra, as written for by Beethoven and his contemporaries, is only the full orchestra with the trombones and the second pair of horns and all extra percussion omitted. The strings are also assumed to be reduced in number, and extra instruments, such as piccolo or cor anglais, are not admitted. Both in treatment and effect this orchestra may be considered to stand midway between the full orchestra and the theatre band, which latter will repay more detailed consideration than it generally receives.

The Theatre Band. The theatre band in its ideal form consists of these instruments: one flute, one oboe, two clarionets, one bassoon, two horns, two cornets, one trombone, one pair of timpani and various percussion, and a small selection of strings. With a band of these proportions the most charming effects can be produced, but alas! it is frequently found to be in a sadly mutilated condition. The horns may be missing, or the bassoon, then the second clarionet is dispensed with, and finally, from motives of economy, it is reduced to the septet band—string quintet, flute and cornet! Nevertheless, there are quite good theatre bands to be found in London and elsewhere, and we may devote a little space to their consideration, because it is most probable that the student's early

Ex. 52. (SCHUMANN)



Ex. 53.



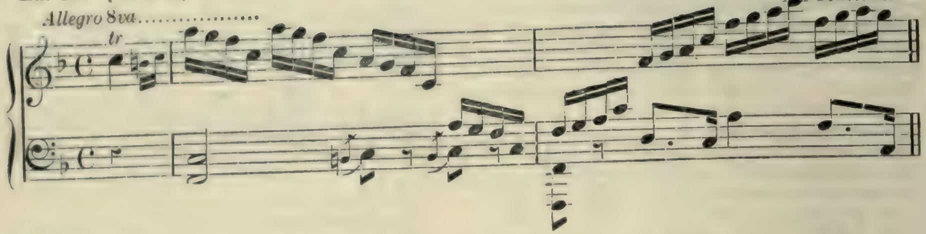
attempts will gain a performance by this combination.

The methods employed with the full orchestra will want some revising for this differently balanced force. Take the brass for instance; the one trombone (a tenor) is apt to appear useless to the beginner, but by writing the cornets low down, three-part brass harmony is possible, and the horns may assist. The first cornet is perfectly well able (and willing) to play the melody, but is easily made to sound vulgar in this capacity, and for artistic scoring these useful instruments should be considered a compromise between trumpets and trombones: moreover, in the absence of horns they will make an efficient substitute.

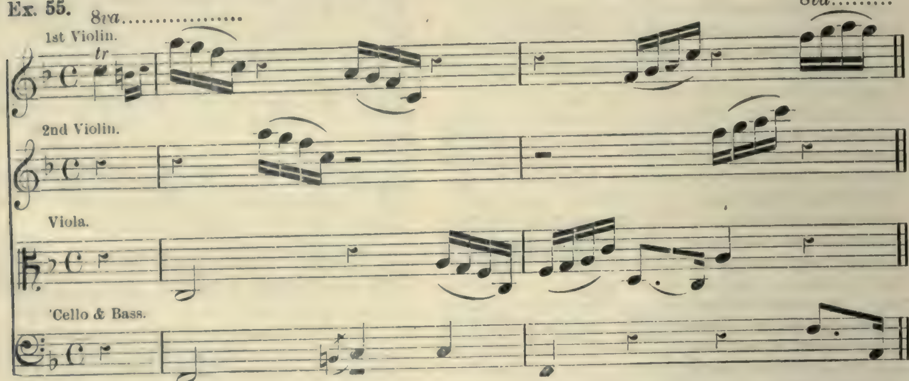
The principal use of the wood-wind will be for solo work, but owing to the paucity of strings they seem to possess more sonority than usual. The clarionets and bassoon may be used for sustaining harmony in the middle.

But it is upon the strings that the chief burden of the orchestra will rest. Even more than before is this the case, and it is but seldom that we can afford to leave them out entirely. Owing to their small number it is not often advisable to divide them, although this has been done at times with wonderful effect. It should be remembered that as the orchestra is somewhat sunken the scoring may be made rather thicker and noisier than would be good for the concert platform. But much will depend on the purport of the music; if it is incidental music, to be spoken through, it cannot be made too light, and the wind had better be eschewed almost entirely. There is

Ex. 54. (CHOPIN)



Ex. 55.



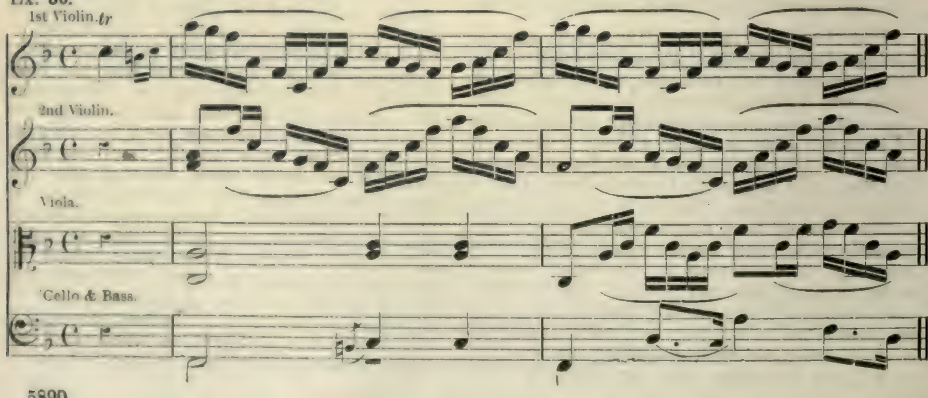
plenty of scope in this branch of orchestration for improvement; the ordinary composer of light music seldom troubles to think out new effects of scoring.

The Wind Band. The wind band, as found in this country, is not a very artistic combination. It consists, approximately, of flute, oboe, two clarionets, two horns (sometimes omitted) two cornets, trombone (sometimes two), euphonium and side-drum, thus bearing considerable resemblance to the theatre band minus the strings. It is unnecessary to say more of this than has already been written; only the simplest kind of music is suitable for such treatment.

The Brass Band. The brass band, such as is heard chiefly in the North of England, approximates somewhat to the military band. The list of their transposing instruments is rather terrifying. The latter is constituted something as follows: Piccolo in E♭, flutes in D♭, oboe, clarionets in E♭, first clarionets in B♭, second clarionets in B♭, third clarionets in B♭, alto clarionet in E♭, four horns in E♭, two cornets in B♭, two bassoons, two trumpets in E♭, two baritones in B♭, two euphoniums in B♭, three trombones, two bombardons in E♭, contrabass tuba in B♭.

In the brass band the wood-winds are omitted; sometimes the clarionets are substituted by saxophones, which take the place of violins; failing these the cornets take their place. It is unlikely that the student will want to write for either of these combinations, moreover some acquaintance with the technique of the instruments is almost a necessity.

Ex. 56.



Ex. 57.

In conclusion a few practical hints may be of service to the inexperienced student. The order in which the instruments are arranged in the score has undergone some modification, but the most usual, and the one which cannot be bettered, is this. First, the wood-wind in order of pitch (reckoning the lowest note of each); the horns, followed by the rest of the brass; next the percussion (to save space they may, with the exception of the timpani, be written on a single line); the harp (if used). In a vocal work the voices may come next, and, lastly, the strings.

Ex. 58.

Piccolo, flutes, oboes, cor anglais, clarionets, bass clarionets, bassoons, double bassoon, horns, trumpets (cornets), trombones, tubas, timpani, triangle, bass drum, etc., harp, voice, first violins, second violins, violas, 'cellos, basses.

The voices are sometimes put in the midst of the strings, just above the 'cellos, but it is better to keep the strings together.

It is customary to put reference marks at short intervals in the score to facilitate matters at rehearsal. Letters are frequently used, inserted usually at the beginning of a phrase or other likely starting-point. A still better device is to number every tenth bar consecutively. This affords additional protection against bars being left out by the copyist.

In copying out band-parts it is well to endeavour to bring a "turn over" at a point where the instrument has a few bars' rest, even if this necessitates wasting half a page of paper. If this is impossible it should be arranged that the string parts each turn over at a different point. For the same reason

Ex. 60.

the two flutes are written in parallel staves on the same paper, and the other wind correspondingly, so that the second may turn over if the first is playing at the end of a page. After a good many bars' rest it is safest to write in a "cue" in red ink, previous to the instrument's re-entry. Attention to these details will assist in obtaining a smooth performance.

CONDUCTING

Anyone who has ever taken part in a pianoforte or vocal duet must have experienced some little difficulty in keeping strict time with his fellow performer. Failure in starting together, and the slight fluctuations of time that are necessary for a musical performance, are generally the blots on such duet playing. If he has played in a quartet the student will have observed this difficulty still more strongly; a nice *ensemble*, as musicians call it, is only to be obtained by constant practice, until not only the work under performance but each of the players' idiosyncrasies become familiar to all the performers. If, now, we imagine a performance by from 20 to 100 instrumentalists, the difficulties will be immeasurably increased. How are they to decide simultaneously the moment of starting? How agree upon the precise *tempo?* (The Italian word "tempo" is used throughout to denote the rate or speed of performance; time, the English equivalent, refers always to the time-signature—that is, the number and value of the notes in

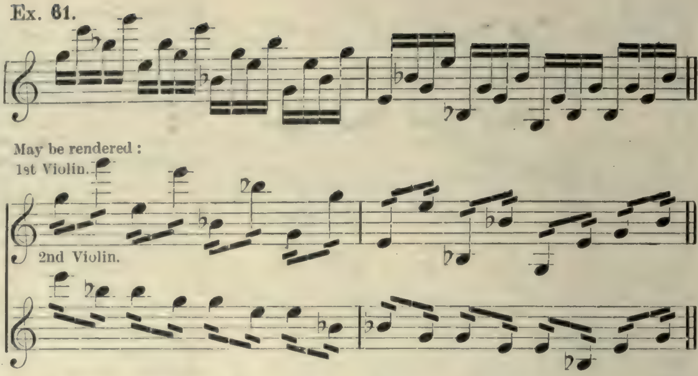
Ex. 59.

the bar.) How, in short, can they give a performance that shall be in any way unanimous without an infinitude of rehearsing? It will at once be obvious that there must be one master mind to direct the powers of the others, and that these must, for the time being, be subservient to the director. We may gather from this what are, in part, the functions of the conductor in the orchestra or choir.

Until about eighty-five years ago the orchestra was conducted by the joint efforts of the principal first violin (who is still called the leader), and a pianist, whose duty it was to fill in any obvious gaps caused by the faulty playing of the

orchestra. This unsatisfactory state of things continued (in England) until 1820, when Spohr, conducting the Philharmonic concert in London, directed the performance with a *baton*, a light staff of wood with which he beat time and gave the necessary indications to the band. The immense superiority of this method was so apparent that it soon became universal and has remained so ever since.

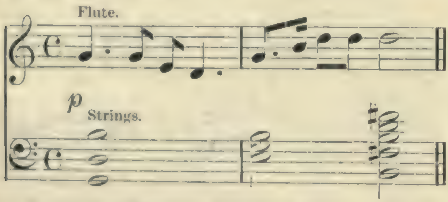
Ex. 61.



The requirements of a conductor may be grouped under two heads: (1) The technical knowledge of the code of signals and gestures used to indicate the different times, rhythms and nuances (light and shade); (2) the æsthetic knowledge of the requirements of the music. It is only the technical side of conducting that can be taught here on paper; the æsthetics of music can only be learned by an exhaustive study of the scores and by listening to performances under the best conductors.

It is necessary that every movement of the conductor shall be deliberate and decided. Any hesitation that he may show will be reflected by the players under him, his indecision will be shown by them, hence he must be very certain of what he has to do. The baton must be held lightly, and the arm and wrist should be free. The baton should be kept sufficiently high to permit of its being seen by everyone, yet no higher than is necessary or the arm will quickly become tired.

Ex. 62. (Dvorâk)



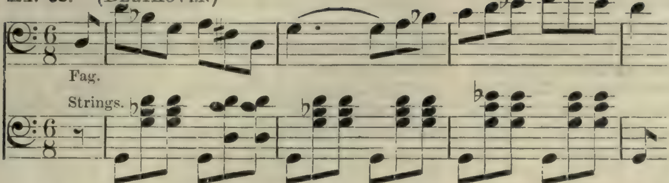
The student will probably know enough of musical theory to remember that the first beat of every bar is the most important; it has normally the strongest accent, and is invariably indicated by the conductor by means of a down beat [1]. The down beat should never be used except on the first of the bar; it follows that the preceding beat—that is, the last of the bar—will be upwards. The remaining beats will be filled in variously, according to circumstances. The principal varieties may be thus tabulated, the direction of the beat being shown (approximately) by means of diagrams. Two in a bar, first down, second up [2]. In a very slow movement in duple time it may be necessary to beat four in the bar. Three beats in the bar, first down, second either right or left, third up [3].

If any of the players are seated behind the conductor the second beat should be to the right, so as to be more visible; if all are in front of him it is quite immaterial which

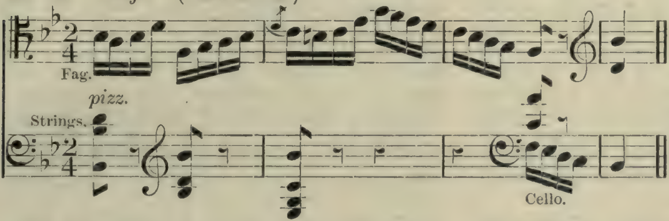
Ex. 63. (Bizet—"Carmen")

Ex. 64. *Adagio*

Ex. 65. (BEETHOVEN)



Ex. 66. *Allegro* (BEETHOVEN)



direction is taken. In a very fast 3–4 movement, such as the scherzo of Beethoven's Pastoral Symphony, there is no time for three separate beats, and "one in a bar" should be indicated by means of a decided down beat on the first and a quick up-beat at the end of the bar.

Four beats in the bar, first down, second left (generally), third right, fourth up [**4**]. Some conductors reverse the directions of the second and third beats.

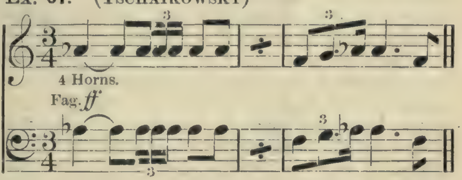
Six beats in the bar. This will be indicated in two different ways—according to whether the time be compound duple (6–8 or 6–4) or a slow triple (3–2 or 3–4). The former case will require two strong beats on the first and fourth of the bar, each followed by two lesser beats [**5**]. The latter will be similar to three beats in a bar with each beat duplicated [**6**]. Six and more beats are only required in very slow tempo, as they will all be found to be compound varieties of duple, triple, or quadruple times.

Eight and twelve beats are both compound varieties of four in a bar, each beat being duplicated for eight, or triplicated for twelve [**7**], while nine [**8**] is three with each beat triplicated.

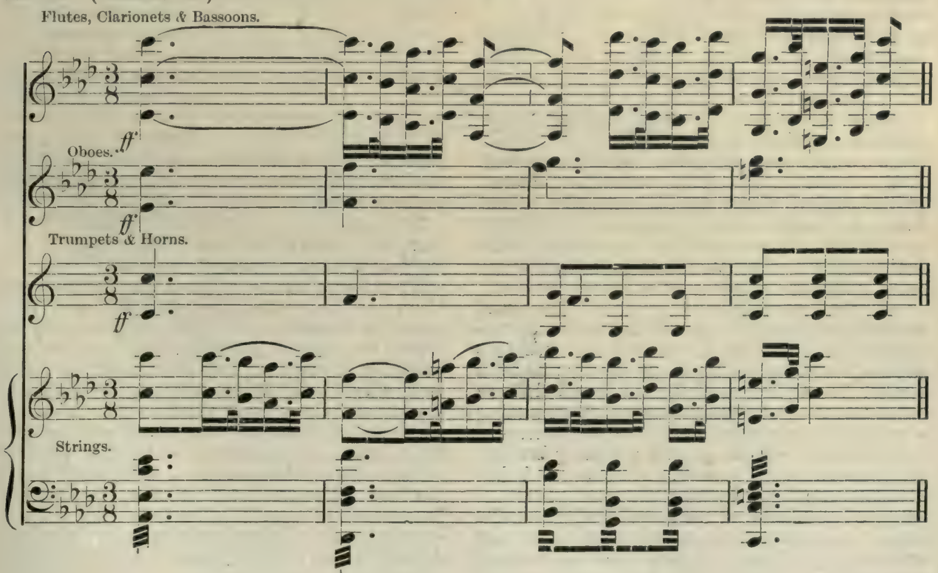
The irregular rhythms of five and seven beats in a bar. These will generally be found to consist of a bar compounded of alternate two and three, or four and three, and may be beaten as such if the first of the bar be made clear. Or five may be beaten as diagram **9** shows.

The movements necessary in beating time should be made freely and decisively, without being jerky. They should be so familiar as to be performed semi-automatically, so that the conductor's whole attention may be given to the requirements of the music. Nothing could be more disastrous than to find the conductor

Ex. 67. (TSCHAIKOWSKY)



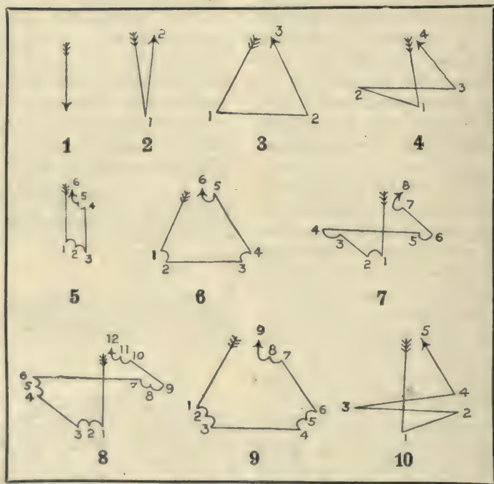
Ex. 68. (BEETHOVEN)



unprepared for a sudden change of time. This, of course, requires that he be well acquainted with the work under performance, and however great his talents, he should not permit himself to follow the example of a certain well-known musician who makes his acquaintance of a new work while he is conducting the first rehearsal of it.

At the start of a piece or movement the baton should be held poised in the air for a few seconds until the conductor is sure of the attention of the whole orchestra, and the first down beat should be prefaced by a short up-stroke, which will have the effect of giving a more decided and definite start. If the music begins on some beat other than the first it is not advisable to beat the whole bar (unless it be indicated in the score by rests), as this may cause confusion to such of the orchestra as are counting several bars' rest; but the starting beat should be preceded by a slight preparatory movement.

Exaggerated Gestures. Apart from the actual beating of time, numerous other indications as to the manner of performance can be given with the baton or by means of gesture on the part of the conductor; but a word of warning must be given against the habit of exaggeration in gesture. Nothing looks worse than to see a conductor enacting movements of fury in order to obtain a *con fuoco* from his band. Any special climactic effects should be spoken of at rehearsal, and a slightly broader gesture may be used in performance by way of a reminder. A pause on a note is held by keeping the baton stationary on whatever beat it occurs—usually the first or strong accent. It is released by a short upward flick of the end of the baton. There should always be a brief interval of silence after a pause on a note before continuing. A pause on a rest is, perhaps, better indicated with the baton held poised in the air as at starting.



1–10. DIAGRAMS ILLUSTRATING TIME BEATS

At the conclusion of a piece the sound should be sharply cut off by a quick upward flick of the baton. It may be taken as a general rule that light and *piano* characteristics should be accompanied by small and delicate movements, chiefly from the wrist, the increasing size of the beats to correspond with the increase of tone required and the gesture becoming broader as the music does likewise. It is assumed that the baton is held in the right hand, but it is often advisable to use the left hand with it for supplementary gestures, indicating breadth and climax—indeed, many conductors use the left hand as much as the right, and would probably be unable to keep it still without an effort. The left hand can also be used for a gesture signifying extreme softness; this is especially useful for a sudden *piano*.

The Position of the Players. When any instrument has had a number of bars' rest it is well for the conductor to make his re-entry certain by giving him a signal. A glance in the direction of the player or players just preparatory to their re-entry will afford the necessary indication for their guidance. It follows that the conductor must know the position of each instrument in the orchestra. This varies a little according to circumstances. In a theatre, band space is usually restricted, and the conductor may congratulate himself if his trombone and timpani are not outside in a passage where he cannot see them! But in the concert orchestra the arrangement is usually thus, from the conductor's point of view: The first violins are on the left, the seconds on the right, the violas in a line in front, the 'cellos sometimes behind the violas, but frequently divided right and left as are the double-basses. Occasionally they play at the same desk as the latter—that is, one 'cello and bass to each desk—this is behind the violins. The wood-wind (flutes, oboes, clarionets, bassoons) sit in a line behind the violas; if the space is small they may be in two rows; behind them are the horns and trumpets, the trombones and percussion occupying the backmost seats. If there is a harp it is placed as near the conductor as possible. This is necessary partly on account of the weak tone of the instrument, but also because the harpist requires more personal attention than the rest of the orchestra.

This arrangement must not be taken as invariable, but merely the usual disposition of the band at London orchestral concerts.

The Conductor's First Performance. Now, our first experience of conducting may occur in several ways. The composer may be asked to conduct a performance of his own work by a more or less well-known orchestra (not otherwise will the student be permitted to experiment on a good band), or he may get together an amateur orchestral society and appoint himself conductor, or he may possibly obtain the conductorship of a theatre band. We will consider each of these possibilities in turn.

If it is his own composition that he is conducting, the student starts with one great advantage; he knows the work in question

thoroughly at the start, and can give all his attention to what he is doing. Very probably there will be only one rehearsal, so he must make the utmost of his time. His first undertaking will be to see that the band parts are all correct, for, however carefully he has looked through them, there will always be mistakes somewhere. He must listen very carefully in order to detect which instrument is in error, and the moment he stops to effect an alteration he will find half the band clamouring to have mistakes, hitherto unsuspected, rectified.

These preliminaries require a clear head and a well-trained ear, besides unlimited patience, if they are to be gone through successfully. If the orchestra is composed of good and experienced players, it is not advisable to stop them too often, except to set right anything important, as they can be trusted to notice and correct little errors for themselves, and it is impossible to get an idea of the music as a whole if the band is stopped every few bars. Any fluctuations of time (*ritardando* and *accelerando*) will be indicated in the parts ; this will warn the band to follow the beat carefully ; but such changes of tempo must be very clearly shown, and must not be made too abruptly.

The Limitations of Amateurs. It requires considerable courage for the beginner to conduct another man's well-appointed orchestra for the first time ; but, given a band of amateurs, the youthful conductor, if he has had any musical training, may feel far more confident and despotic. He should be warned, however, not to be too ambitious, but to suit his programme to the capacity of his orchestra ; for the majority of amateur instrumentalists are, to say the least of it, indifferent readers. So it will often be advisable to take to pieces any difficult passage that may present itself, rehearsing, say, the wood-winds alone, to obtain the necessary *piano*, the violins by themselves (more especially the seconds) until they can play that semiquaver passage nicely together ; the brass, if there is any, that we may hear who it is playing a wrong note, and so forth. Before conducting well-known works the student must ascertain the correct tempo throughout, and should not deviate from the traditional reading without sufficient reason until some years of experience lie behind him.

Conducting Theatre Bands. We now turn to the theatre band. This is a capital medium on which to expend one's embryo efforts of conducting, besides being a fruitful source of experience. Its composition varies from the string quartet, cornet, and piano of the provincial "smalls" to the well-developed orchestra now to be found at a few of the best London theatres. It differs in many respects from either of the varieties of orchestra that we have so far considered. It is smaller in size ; it occupies usually a more enclosed space ; is frequently out of sight of the listener, and it is not listened to with very much attention. It is on account of these seeming drawbacks that the band is more easily controlled by its conductor. He can do things which would be impossible in a concert-room ; on an emergency he may even speak with the players. The necessity for this facility of control is seen when the band is playing music incidental to the stage performance. It may have to follow the action of the play, which only the conductor can see ; he may have to make sudden alterations of tempo, pauses where none exist, repeat sections *ad libitum*, or leave out repeats.

Impromptu Work. At times the conductor may have to give out band-parts and perform at sight extra numbers to fill in a delay between the acts ; in the middle of this the curtain will perhaps rise, and the conductor must stop abruptly at the nearest cadence. This sudden stoppage can be indicated to the band by a look and an appropriate gesture ; a *ritardando* will even suffice for the experienced bandsman. If there is no possible stopping-place in the music a *diminuendo* until the sound is practically inaudible is the only resource. In dance music, where every section is marked with repeats, the conductor is accustomed to tap the desk twice in quick succession to indicate "Go on, omit the repeat," where such omission is desired. It will be found that much light music of which band-parts are obtainable is unprovided with a full score, and the conductor has frequently to be satisfied with a first violin part ; but music of this character is so simple that this is not a great drawback. In very small orchestras the conductor may be expected to play first violin himself, leaving off to beat time with his bow when necessary.

CHOIR TRAINING

In writing for the purpose of assisting the inexperienced student over his earliest attempts at choir training, it is necessary to consider in what circumstances he is most likely to need this assistance. It is not in connection with a well-appointed choral society that these initial efforts will take place. We are writing, be it remembered, of choir *training*, not choir *conducting*, and in order to obtain a post as choirmaster to an even moderately good choir a certain amount of previous experience is almost a necessity. It is probable that the student's first efforts will be expended on a small and very indifferent church choir, the post of choirmaster not infrequently being combined with that of organist.

That such a choir will most likely be small, badly balanced, and badly trained (or else not trained at all) is in some respects an advantage, as the opportunity is offered of learning the work from the very beginning ; and if the student is anything of a musician he will instinctively realise how much there is for him to do, and in his energetic attempts to reduce chaos to some order he will lose that feeling of "newness" to the task, and experience will rapidly come to him.

The Arrangement of the Voices. A choir, if it is to be worthy of the name, should be divided into four parts or voices—trebles, altos, tenors, and basses, and this arrangement should be adhered to wherever possible, as by far the greatest amount of choral music is written for this combination of voices. The first difficulty

to be encountered is to select the members for these four parts so that a tolerable balance is obtained. If the trebles are sung by boys' voices, as is very usual, they will require to be more numerous than the other parts; indeed, they may be equal in number to the other three combined without causing any serious disproportion. The altos generally give the choirmaster the most trouble. If there are ladies in the choir, well and good, but if not, the male voice is rare and difficult to obtain, and boys' voices will have to be employed for these. A fair proportion for a choir of 20 would be: 10 trebles, 3 altos, 3 tenors, 4 basses. If the trebles are sung by women the proportion to the other parts may be rather less. Thus our choir of 20 might contain 8 trebles, 4 altos, 4 tenors, 4 basses. Perhaps a further improvement would be an additional bass or two.

It has been said that the functions of organist and choirmaster are generally united in one individual, hence it will be obvious that at the preliminary practices any organ accompaniments are out of the question; the choirmaster will want to give all his attention to conducting the choir, any accompaniments that may be necessary to preserve the intonation (and the less the better) can be played on a piano.

Preliminary Instruction. It will perhaps be as well if we assume that the choir we are considering is entirely new-formed, and has had no previous training. Our first care in this case should be to take the younger members by themselves and impart some instructions in the rudiments of music, paying more especial attention to such matters as concern the relative values of notes and rests, time signatures, and the like. A blackboard ruled with music lines should be provided, and exercises in time written thereon should be sung at sight and repeated a few times until absolute accuracy of notes and rests has been acquired. The above is a specimen of exercises for beginners, the conductor indicating each beat with a baton, first quite slowly and afterwards at a quicker speed.

Such exercises should be invented by the choirmaster on each occasion, and not used over again, as they are intended to be preliminary to reading at sight. They should be sung to the sounds "ah" or "la," the broad vowel sound being generally preferable to a closer one.

Next, simple intervals may be introduced into the exercises; and now it must be decided whether *Tonic Sol-Fa* or *Staff* notation is to be taught. It is not proposed to enter here on a discussion of the merits of these rival systems. The choirmaster will probably have a predilection for one or other. The Tonic Sol-Fa is undoubtedly the simpler, and is said to give the best results with pupils of limited intelligence. Staff notation, on the other hand, renders a vastly larger repertoire of music available to its disciples.

Until the choir has attained considerable facility in singing simple diatonic intervals, no attempt should be made to introduce words. The syllables Do, Re, Mi, Fa, Sol, La, Ti (or the Tonic Sol-Fa equivalents) can be used for the degrees of the scale.

Exercises. The next stage should be the introduction of simple two-part exercises, which the choirmaster may either invent for himself or else obtain from one of the many collections published for the purpose. Both parts should be practised separately, especially the seconds, before they are sung in combination. This remark applies even more forcibly with regard to the full practice, which should take place at least once a week; each single part must receive separate rehearsal before the *ensemble* is attempted.

We have now advanced to the stage when easy four-part anthems may be rehearsed. And here it may be as well to repeat the advice just given—until the music is fairly well known, no words should be sung, only the syllables representing the notes of the scale. The reason for this is obvious. We do not wish the attention of the singers to be divided between two entirely different and almost equally difficult tasks, for the correct pronunciation of words in singing is frequently a source of much trouble, even to such choristers as have had a good education. The vowel-sounds in the North of England are often compounded in a fearful and wonderful manner; for that matter, London itself has some strange perversions of English pronunciation, such as the conversion of the long ā into ie, and so forth. It follows that exercises in the simple vowel-sounds will be required. A series of such sounds may be recited or sung to a monotone. For instance:

ā	â	ă	ē	ĕ	ī	ĭ	ō
May	ma	mat	neat	net	bite	bit	note

ŏ	ōū	ŏŭ	ŭ	ū	āū	ow	oy
not	boot	foot	but	tune	caught	now	boy

These comprise all the vowel sounds in the English language. Among the consonants that will require attention the letter R may be picked out, especially as a final, and before a vowel; indeed, almost all final consonants will show a tendency to be eluded, and the letter H will probably want some attention. Some attention, too, must be given to breathing. If not already marked, the teacher should indicate the places in the music where breath is to be taken, and see that it is done quickly, and above all, silently.

Blending the Parts. As regards *ensemble*, or the nice balancing of the parts one against the other, the members of the choir should be taught from the very first the necessity of listening to the other parts, and so endeavouring to make their own efforts blend with the others. They must not consider their own part as the most important, unless it is solo work they are doing, but should try to sink their own individuality for the benefit of the choir as a whole.

ORCHESTRATION *concluded*; *followed by* SINGING

TREES WHICH YIELD CORK

The Bark of the Cork Oaks. Removing the Cork Layer. Cooking the Bark and Making Corks. Sterilising Corks. The Uses of Cork

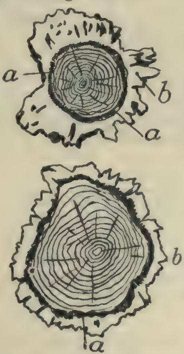
Group 23
APPLIED BOTANY
12

Following on CANES AND BAMBOO from page 5725

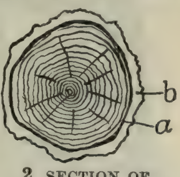
There are two closely allied cork oaks which yield cork—*Quercus suber L.*, and *Q. occidentalis.* These two species belong to the evergreen oaks, and have the following characters: Leaves, oval-oblong; entire, or more frequently toothed and the teeth jagged; $\frac{1}{2}$ in. to 2 in. long; width about 1 in.; branches rather scanty; shade slight; root system strong and extensive, the roots frequently showing on the surface; the growth varies with the locality, but is generally slow. The most favourable position for the tree is on southern slopes, and the best cork and more rapid growth of the cork-tree are produced on granitic, siliceous, and slate soils. It does not thrive well on lime soils, and should have abundant moisture with good drainage.

Where the Cork=tree Grows. The cork oak is found in the southern regions of Europe and on the northern shores of Africa. It grows in great abundance in Spain, especially in the provinces of Gerona, Cáceres, Andalusia, Huelvas, Seville, and Cadiz. In Portugal the tree is found in the basin of the Tagus; in France, the Southern Pyrenees, Var, Maritime Alps, and Corsica; in Italy, Sardinia, Sicily and Tuscany; in Greece, Morocco, Algiers, and Tunis. The average temperature of the countries in which the cork oak flourishes is 59° F. In France the tree grows at an elevation of 1,900 ft. to 2,200 ft.; but in Algiers at an altitude of 4,000 ft. The tree is usually raised from seed, the large and sweet acorns producing trees of full and regular growth and yielding the finest cork, while the small, bitter acorns produce trees of coarse and inferior nature. The method of planting is in furrows 5 ft. to 7 ft. apart between rows of grape vines which afford shelter, the acorns being placed from 2 ft. to 3 ft. apart. Thinning is the only further treatment which is required as the trees grow.

The Cork Harvest. The first gathering of cork takes place when the tree reaches the age of forty years, about 7 lb. of cork per tree being yielded. As the trees grow they are thinned out, till at 120 years there are about 40 trees per acre. The average yield at 120 years may vary from 500 lb. to 1,000 lb. of cork at a single harvest. The first harvest is the natural cork, and has a rough and woody appearance. It is of no use to the corkmaker, but finds employment for garden decorations. This natural or wild cork [1b] develops as the tree grows, and when the oak has attained a diameter of from 6 in. to 10 in. the wild bark is removed, exposing the mother layer [1a], or *liber*, from which the commercial cork develops [2b]. The process of barking is simple, but requires care, or the tree will be injured, if not killed. The barking is done when the tree is in sap as at that time there is no difficulty in separating the corky bark. The proper time is when the first mounting of the sap has somewhat slackened and when the new leaves have developed. In Algeria the proper time is thought to be the end of May, but it is later in France. The first harvest of commercial cork takes place from six to ten years after the removal of the wild bark. In gathering the bark a circular cut is made round the tree, care being taken not to penetrate the mother layer; a similar circular cut is made at the bottom of the tree, and these are connected with vertical cuts. Then, beginning at the upper portion, the incision is gradually opened with a hatchet [3], and the cork layer detached, the edge and handle of the hatchet being both employed in the process. If the trees are not more than 24 in. in circumference, the cork is taken off in one piece, which is called a cannon, from the facility with which it assumes a curved shape after removal. Larger trees have the cork removed in longitudinal pieces. The mother layer develops a new growth of cork, and in from seven years to ten years' time the tree is again barked. The trunk of the tree is not entirely stripped at each barking, a zone being cleared to a height of 30 in., and at each barking gradually extended and alternated.



1. SECTIONS OF WILD CORK-TREE
a. Mother-bark layer
b. Wild bark

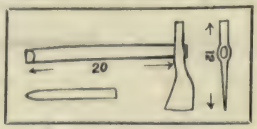


2. SECTION OF DECORTICATED CORK-TREE
a. Mother-bark layer
b. Commercial bark

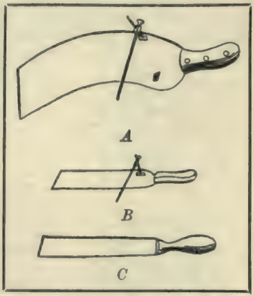
Preparing the Cork. The cork taken from the trees is submitted to a cooking process, with the object of closing the pores and increasing the elasticity. The cork loses weight in the process but increases in volume about 20 per cent. The cooking is effected in cauldrons either of a cylindrical or rectangular form. A vessel of about 6 ft. square will hold from three to five cwt. of cork. The cork is flattened and held in that position by weights, water is added, and the cork boiled for about an hour. After boiling, the cork is taken out, cooled, and then submitted to a process of taking off the hard crust or raspa. This is either done by hand or machine. The tool used for the hand process has a curved blade and short handle. A workman can scrape from two to three square metres daily, the loss in weight of the cork being from 20 to 30 per cent. The loss is greater when machines are used—the two systems of machine scraping being the Besson and Tousseau. The former, propelled by steam, consists principally of horizontal spindles supplied with comb-like teeth and turning at a great rate, about 900 revolutions a minute. The Tousseau scraper attacks the cork by means of knives with vertical edges, carried on a vertical iron shaft, revolving at the rate of 1,400 turns a minute: the machine works like a brush. This machine is simpler than

the Besson and the slabs of cork suffer less damage than when worked by inexperienced workmen. The cork slabs are next trimmed to proper shape and graded for different purposes, the finest grade being that used for the manufacture of champagne corks.

Making Corks. Before working up the cork it is again cooked for about half-an-hour, and piled up in a damp place so as to keep it soft, in which condition it is more easily worked. The slabs are divided into strips (*rebanadas*), the width of which is equal to the length of the cork, and in such a way that if the cork be placed in the position occupied by the slab on the tree the fibre would run in the same direction. The workmen cut the strips by means of a long knife with flat surface and curved edge called *cuchella de rebanar* [4a]. The strips are then cut into squares [4b] and the edges cut to make them octagonal pieces, which are then trimmed into shape by means of a long knife [4c] kept very sharp. The knife is not moved, but the cork is drawn over its edge by a circular curving motion. The knife is kept sharp by being whetted on a board on each side after every cut. Bungs and corks of large size are cut in the contrary direction as regards the fibre, and are in consequence not so effective as stoppers.



3. DECORTICATING HATCHET



4. CORK-CUTTING KNIVES
a. Strip-cutter with gauge
b. Quartering knife *c*. Rounding knife

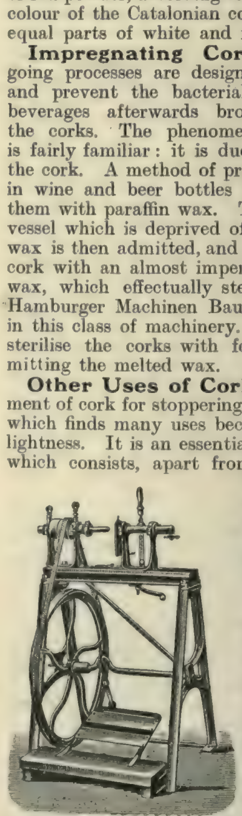
Machine-made Corks. Many different machines are employed to make corks, and all consist at the base of a knife, the blade of which is placed horizontally, being generally joined to a piece of wood, and to which a backward and forward movement is imparted similar to that given by a carpenter when using a plane. In moving, the knife turns the square cork, which, being attacked by the knife, has cut from it a strip more or less thick, according to the distance from the axis of the cork and the edge of the knife. If these are parallel, the result is a cylindrical cork; otherwise the cork is conical in shape. The cork is previously prepared by a drawing-off and a quartering machine.

The first cuts the cork sheets into strips, and is generally provided with a self-sharpening arrangement for the knives, while the quartering machine cuts the cork into squares for straight or tapering corks, different adjustments being made, according to the product desired. The cork-rounding machine is the one which actually finishes the corks, a machine being capable of making 1,000 corks an hour, and adjustable to make corks from ½ in. to 5½ in. in diameter. Another variety of machine works on the principle of a cork-borer [5]. Such machines are suitable only for straight corks, and the boring is done from the strips, quartering not being needed.

Finishing Corks. After cutting, the corks are boiled and kept in a cool place for a few days, and then sorted into the various sizes. The cork-maker has a large basket, or several of them, in which he places the corks according to size and quality, but this first classification is not sufficient, and the corks are re-sorted upon a table. To classify according to size, suspended boxes with a kind of grating resembling Venetian blinds at the bottom are used, the size of the opening allowing a particular size cork to fall through. Cork-counting machines are also employed in large cork factories, and the corks are branded with the name of the firm, if required. In most foreign cork factories the corks are submitted to a bleaching process if their colour is not right. The solution used for the process consists of a weak solution of hydrochloric acid, oxalic acid, or binoxalate of potash. Fumigation with sulphur is also sometimes practised. The colour of corks after these processes is often unnatural, but is improved by putting them into a revolving polisher with a little white or red powder, according to the tint desired, the red colour of the Catalonian corks being imitated with equal parts of white and red powder.

Impregnating Corks. Some of the foregoing processes are designed to purify the corks and prevent the bacterial contamination of the beverages afterwards brought in contact with the corks. The phenomena of "corked" wine is fairly familiar: it is due to bacteria or fungi in the cork. A method of preparing corks before use in wine and beer bottles is that of impregnating them with paraffin wax. The corks are put into a vessel which is deprived of its air, melted paraffin wax is then admitted, and fills up the pores of the cork with an almost imperceptible film of paraffin wax, which effectually sterilises the corks. The Hamburger Machinen Bauanstalt have specialised in this class of machinery. Another method is to sterilise the corks with formaldehyde before admitting the melted wax.

Other Uses of Cork. Besides the employment of cork for stoppering bottles, it is a substance which finds many uses because of its porosity and lightness. It is an essential ingredient in linoleum, which consists, apart from the jute canvas and backing, of cork, pigment and a cement made by melting together oxidised linseed oil, kauri gum, and resin. For this purpose the cork is finely powdered in a "devil" disintegrator, or similar machine. Coarsely powdered cork is used for cork carpet. Cork soles are cut out on a press, the punching knives being shaped like the sole of a boot. Cork mats are cut out by revolving circular knives, the same principle being also applicable to the thinnest sheets, known as cork paper. The last named finds a use for lining hats. Cork, being a bad conductor of heat, is sometimes used for insulating boilers or padding the walls of buildings. Its use in artificial limbs is due to the lightness of cork.



5. CORK-CUTTING MACHINE

Continued

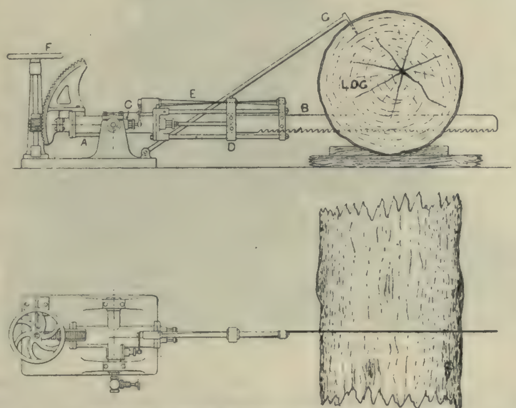
LOG-SAWING MACHINES

Cross-cut Saws. Log Frames. Methods of Driving. Feeds. Deal Frames

Continued from page 5669

By FRED HORNER

THE first operation upon logs coming into a sawmill is to part them off into suitable lengths for cutting down into boards, etc., unless it should happen that the whole length of a log is wanted. There are several kinds of machines for this work, employing reciprocating and circular saws, and driven by steam, belt, or electricity. They are either fixed in a convenient position in the mill or are rendered portable, to be shifted alongside logs, thus avoiding the troublesome work of moving about logs of several tons' weight. A direct steam-driven machine (W. B. Haigh & Co., Ltd., Oldham) is shown in elevation and plan in 7, with a log in position. The steam cylinder, A, by means of its piston reciprocates the piston-rod, and the saw-blade, B, attached thereto, the teeth being set to cut on the inward stroke. The reversal of the piston is not effected by ordinary valve gear, but steam is admitted and cut off by a valve, C, operated through the medium of the guide, D, which, sliding on the guide-bars cottered to the front cylinder cover, turns a flat twisted strip, E, as it moves, and causes the latter to turn a lever, alternately opening and closing the valve. The strip, E, turns easily by its round ends in bearing holes. The cylinder, A, is suspended by spigots in trunnion bearings on the baseplate, and a quadrant bolted on the rear has worm teeth upon it, engaging in a worm on a vertical shaft turned by the handwheel, F. This mechanism enables the attendant to raise or depress the saw-blade and to feed it downwards through the log. The latter is tied to the machine by two long rods pivoted to the baseplate, and having spiked ends, which are hammered into the log. The reason for making the saw cut on the inward stroke is that it is thus put in tension and does not buckle as it would if pushed outwards. It may be mentioned that this method of steam driving was originally devised by Messrs. Ransome, of Newark-on-Trent.



7 DIRECT STEAM-DRIVEN CROSS-CUT SAW

Felling Trees by Sawing. An adaptation of this mechanism is made for tree-felling by turning the blade on its side, and employing a horizontal quadrant guide to let it slew around as the tree is cut through. A wedge is driven into the saw-cut after the blade in order to keep the kerf open and prevent excessive friction on the blade. When these machines are portable, the steam is conveyed by a flexible hose from the boiler, which may serve several fellers and cross-cutters. Trees 3 ft. or 4 ft. in diameter can be felled in five or six minutes. Some large tree-fellers are mounted on wheels like a gun. A hydraulic jack, with a concave-headed ram, is employed to raise trees which have been felled, and are being cross-cut, so as to prevent the blade from being pinched in the kerf; wedges are sometimes used instead.

Another class of cross-cut machine is driven from an ordinary steam cylinder, with its connecting rod working on to a crank-disc, which in turn revolves a bent crank of large throw, reciprocating a connecting rod coupled to the saw-blade, which slides in guides, and is fed downwards by a quadrant gear. Figure 10 shows a type of machine that may be operated either by belt, or by electric motor. In the former case the fast and loose pulleys are put on the end of the crank-disc shaft; in the latter the motor spindle is coupled to the shaft end. The flywheel conserves energy to keep the machine running steadily. The blade is fastened to a light steel sliding bar running in guides and driven by a connecting rod from the crank-disc. The guides are attached to an arm pivoted on bearings, and the feed is imparted by the hand wheel and screw in the vertical slide. The heavy weights seen at the rear balance the weight of the mechanism at the front.

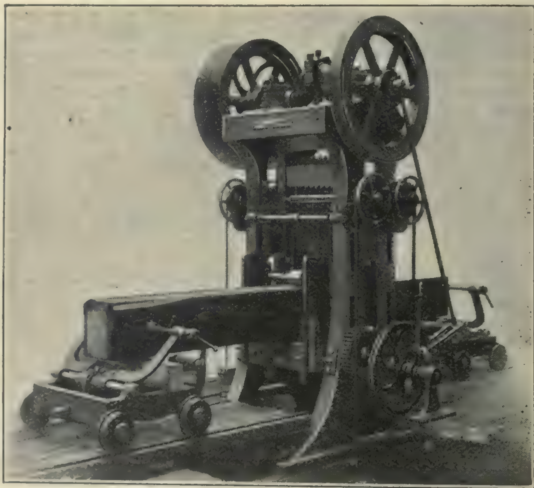
Circular saws are not used so much as these reciprocating blades, partly because of their greater cost and the limitation in the diameter of log that can be cut through, but they work more rapidly. A favourite type of machine is that represented in 8 (Thomas Robinson & Son, Ltd., Rochdale). The circular saw spindle is mounted in bearings forming part of a carriage which slides on a horizontal bed lying at right angles to the log. The saw is rotated by mitre gears driven from the shaft above the bed, and turned by the fast pulley of the pair at the end of the bed. The carriage is fed by a coarse-cut screw—both forwards for cutting and backwards for return.

The machine takes saws up to 6 ft. 6 in. diameter, cutting through logs 35 in. diameter. Circular saws of pendulum type are also employed, the saw being carried in a long pivoted and counterbalanced frame, and driven by a pulley belted from another pulley encircling the pivot shaft, so that the drive is not affected by the swinging positions of the saw.

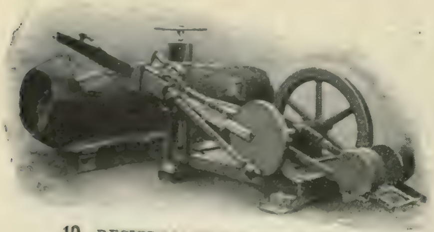
Breaking-down Machines. Logs are divided longitudinally into portions of various sizes, known under different names [see Dictionary, which follows a later article], and the operation may be effected on a single machine or in two successive ones. Boards may be cut direct from the log, or the latter may be first broken down into deals (in the case of pine), flitches, or planks, which are further treated on other machines.

Log saws are those which begin work upon the logs and balks; *deal* and *flitch frames* are used for resawing the deals and flitches into boards. The first class of saw may be either a *log frame* or *timber frame*, a *reciprocating saw* or single-blade *board-cutter*, or a band-saw. The deal and flitch frames are of reciprocating type. Circular saws are also employed for breaking down logs. Each kind has its advantages and disadvantages, which may be conveniently discussed as the different types are illustrated.

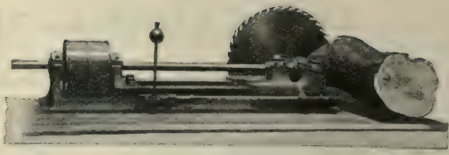
Log Frames. The log or timber frames comprise a vertical *housing* through which the logs pass, and are divided by a number of saw-blades moving up and down. The frame saw is the oldest type of machine, and is employed most extensively, though it is slower in operation than later machines which are coming rapidly into favour. The advantage is that logs may be divided accurately into boards, etc., without re-sawing, one pass sufficing for the operation. Means are provided for feeding the logs through at varying rates, either by rollers in contact with the wood, termed *roller feed*, or by supporting the log upon carriages travelling, by rack and pinions, on runways, termed *rack feed*. The roller feed is suitable for straight, even timber, on which the rollers can get a good bite all along; the rack feed is used for crooked, uneven logs, or on those which are frozen, and would not be gripped easily by rollers. The advantage of the roller feed is that the logs can be passed through quickly in succession, and there are no carriages to be



9. OVERHEAD-DRIVEN LOG FRAME



10. RECIPROCATING CROSS-CUT SAW
(A. Ransome & Co., Ltd.)



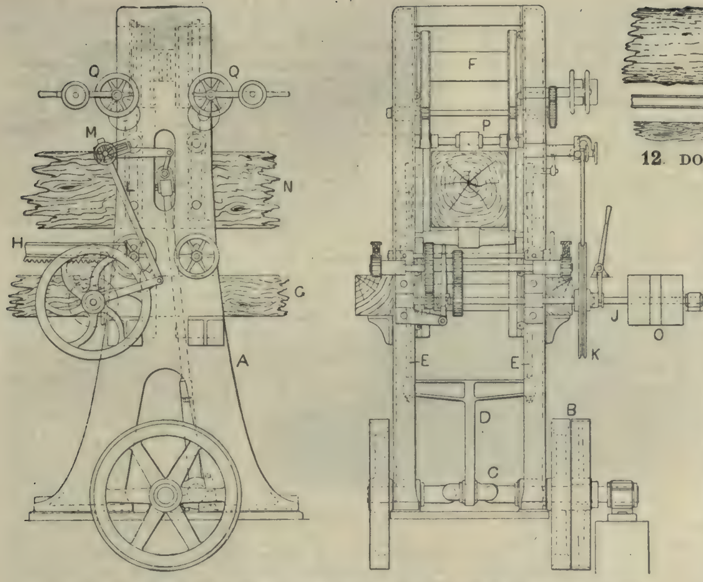
8. CIRCULAR CROSS-CUT SAW

run back for starting fresh logs, as in the rack feed, the result being a considerable saving in time.

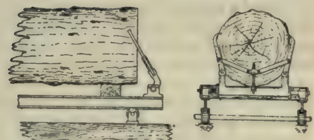
The rack feed is more positive, and is better for hard woods, on which rollers are liable to slip under the strain of feeding. The rollers and the carriages are actuated by a feed motion derived from the driving mechanism of the machine, arranged so that the feed is imparted just before or on the down stroke of the saws, which, as they cut only in one direction, cannot have a continuous feed, as band or circular saws may. The saws, which, to work efficiently, must be strained very tightly, are fastened in a *saw frame* or *working frame*, or *swing frame*, or *saw gate*, with cotters and *buckles*, and the frame slides up and down between guides which are adjustable to take up slackness. The number of saws depends on the width of the frame and the class of work done.

There may be only one, two, three, or four saws for opening out a log into thick pieces, which may or may not be resawn, or 40 to 50 blades can be used for cutting a log into thin boards. The working frames are constructed in as light a manner as possible, consistently with strength, in order that the moving mass shall not interfere with the easy working of the frame, at the high speeds required, necessitating hundreds of reversals in a minute. The frames are built up of wrought iron or steel, and in many cases light steel tubing is employed, being a very suitable form combining stiffness with strength. A frame must be strong enough to resist bulging out sideways when all the saws are cottered, or *hammered up* in it, otherwise it will bind in its guides, although many machines embody provision for a little latitude in this way, so that if the frame is bulged it will still slide freely.

In addition to the variations in construction already mentioned, there are other differences in log frames, which chiefly concern the methods of driving. Belt pulleys may be located below, or above, driving a crank-shaft operating the saw frame by connecting rods; steam driving, either direct or through the medium of a shaft and cranks, is another method, and electric motors are also being applied, above or below, with the advantage that much of the underground shafting and belting



11. LOG FRAME WITH RACK FEED (W. B. Haigh & Co., Ltd., Oldham)

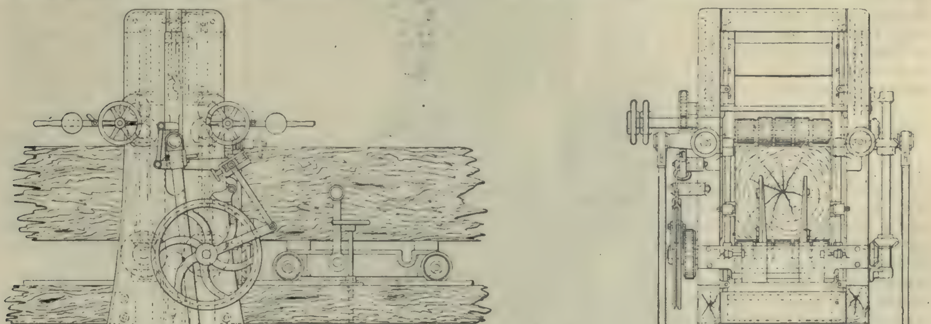


12. DOG FOR GRIPPING LOGS

mentioned previously is abolished. If the motors do not drive each machine direct, they may actuate a line of shafting, from which several machines derive power, there being an advantage in this, that motors of less power can be installed, since it is scarcely possible that all the machines will be consuming the maximum power simultaneously, a few being sure to run light.

Log Frame with Rack Feed. Taking up the details of log frames, we first give side and front elevations [11] of a 24-in. frame, with rack feed, by Messrs. W. B. Haigh & Co., Ltd. The upright cored frame, A, which is seen to be well spread out, in the side view, receives all the working portions, and ensures rigidity and freedom from vibration. The fast-and-loose pulleys, B, drive the crank-shaft, C, at 140 revolutions a minute, the heavy flywheel on the other end of the shaft steadying the running, which is apt to be irregular as the saws cut on the down stroke and run free on the up stroke. The combined connecting-rod and crosshead D couples the crank-pin to the two long rods EE which are pivoted to the saw frame F sliding between the guides in the frame, A.

The timbers GG, bolted to brackets on the frame A, are for the purpose of carrying rails upon which a *rack carriage* runs, the top of G being at the floor level of the mill, the rest of the frame and driving mechanism lying, therefore, below the floor. A bit of the table is seen at H, and on top of this

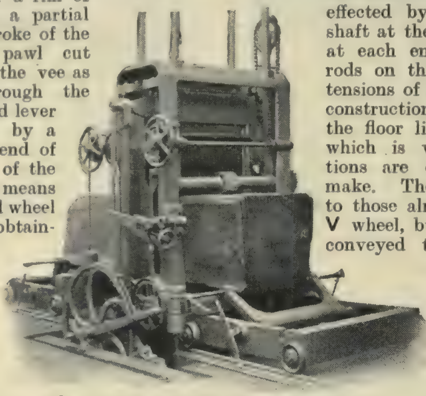


13. ROLLER-FEED FRAME

the log is supported in a manner which will be seen later. The *feed* to this table is effected through a row of rack teeth on its underside, worked by pinions on a shaft lying immediately below it, and connected by two sets of gears with another shaft, J, having a large wheel with a rim of V section. This is given a partial rotation at each down stroke of the saw-gate by a smooth pawl cut eccentrically to jam into the vee as the lever L lifts it, through the medium of the short slotted lever M, rocked up and down by a lever coupled to the top end of one rod, E. The position of the lever L on M is variable by means of a short screw and a hand wheel which makes provision for obtaining different rates of feed to the balk N. The device, which is universally adopted, is termed the *silent ratchet*, or *silent feed*. A rapid motion can also be imparted to the table in either direction for bringing a log up quickly or returning the carriage for another log. The belt pulleys O carry open and crossed belts, either of which may be shipped on to the central fast pulley to drive through the shaft J, clutched into or out of action, and connected to the pinions driving the table through two sets of gears having varying ratios, either of which can be employed, for fast or slow movements. The timber is held down firmly by rollers, P, on shafts which are supported in sliding racks moved up and down by pinions and gears, operated by the hand wheels QQ, which have weighted levers allowing a little freedom of movement should the log require accommodation in passing through. Two rollers are also located beneath the log, so that it is held quite steadily.

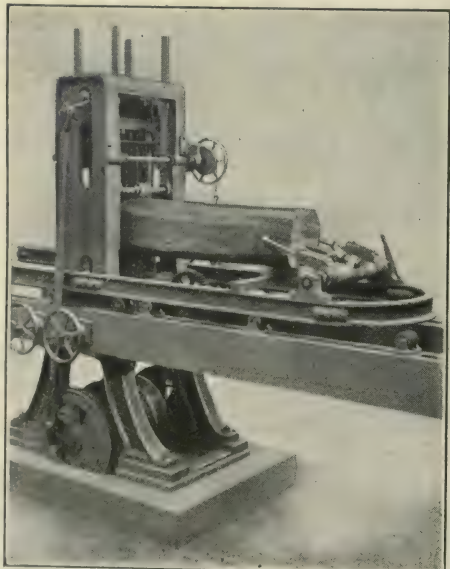
Figure 12 illustrates a class of dog commonly employed for gripping the log at each end upon the rack table, the pincers or jaws being connected with toggle levers, and opened or closed by means of a central screw. The set of levers is carried on a shaft held in bearings, and a screw is placed at one side to enable the attendant to adjust the dogs laterally to suit crooked timber.

Log Frame with Roller Feed. The roller-feed frames, of which an example is given in 12, propel the log by the contact of fluted rollers, positively driven; in some machines rollers are used only beneath the logs, the top rollers being simply plain, but in the *compound* types both top and bottom rollers are driven, thereby giving a powerful drive which will even carry logs covered with ice past the saws without slipping. In the drawing of the machine (also by Messrs. Haigh) several points of similarity to the previous design will be noted, but the mode of driving is different, being effected by belt pulleys located on the shaft at the bottom rotating crank-discs at each end, and moving connecting-rods on the outside, connected to extensions of the saw-gate. This form of construction enables the height below the floor line to be reduced, a feature which is valuable when deep excavations are difficult or inconvenient to make. The feeds are derived similarly to those already described, with a silent V wheel, but the motions have to be conveyed to the four shafts of the serrated feed-rollers, which are revolved simultaneously by connecting them up with mitre gears and shafts. The log is supported on two carriages, one being shown in the side elevation, and separately in plan view, running by trolley wheels on the rails secured to the top of the beams that are flush with the mill floor. Each carriage has a pair of pivoted arms carrying screws which clamp the timber, and as the arms are held on a shaft they are able to slew a little should the log rise or fall in passing through the feed rollers. The screw forming part of the pivot shaft [see the plan] provides for side adjustment to suit crooked logs. The machine is arranged also to saw deals, for which purpose a couple of *fences* (seen in the front view) are placed in position, and side pressure is given to the deals by flanking levers which are mounted on vertical shafts, twisted by quadrant racks operated by hand wheels.



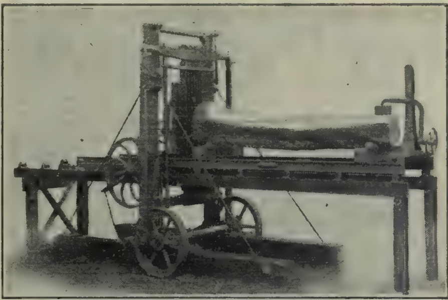
14. HEAVY ROLLER-FEED LOG FRAME

When it is impossible to get out deep foundations in the mill, *top-driven* frames are installed, by which the length of frame below the floor is reduced to a small amount. Figure 9 (Thomas Robinson & Son, Ltd.) is an example of an overhead-driven type, actuated by a belt pulley on the crank-shaft on top of the frame. This pulley and another on the other end are heavy and counter-balanced, to act as flywheels; a loose outer pulley receives the belt when the machine has to be stopped. A roller feed is given to the logs, one being shown in position, resting upon its screw-dog carriages. A deal-sawing apparatus can be combined with the machine, for which two fences, seen at the front, on each side of the log, are moved across into position to guide



15. UNDER-DRIVEN LOG FRAME

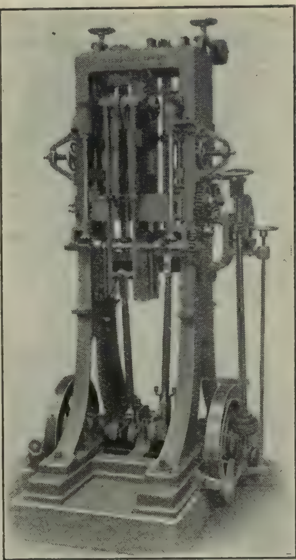
the deals. A good view of an *under-driven* machine by the same makers is given in **15**, having rack feed. The dogs gripping the piece of log being passed through are of the toggle type, and the rack table is seen resting upon its rollers carried upon the horizontal timbers. A very heavy Robinson frame, constructed for cutting up massive logs of round or square section, is illustrated in **14**, with a big log in place. The capacity of the largest machine is up to logs 48 in. by 30 ft., the pulleys making 100 revolutions per minute. The connecting-rods work on the outside of the frames from crank-discs below the floor, and the feed is by a silent ratchet and fluted rollers of *duplex* or compound pattern, the bottom ones being driven by spur gears and the top ones by pitch chains. The frame as shown is carrying 36 saws.



16. SEMI-PORTABLE BREAKING-DOWN FRAME

Semi-portable Frames. In what are called *colonial* breaking-down frames the uprights and horizontals are often constructed of timber, built on the spot where the machine is erected, the makers of the frame supplying only the iron portions. The machines are then of *semi-portable* type—that is, they can be dismantled and removed without much trouble. Figure **16** shows a machine of the class for use in forests, as it appears before the flooring is built around the table.

Two heavy timbers are laid on the ground, and the iron uprights are attached to them, and steadied with sloping tie rods. The horizontal timbers for the table rollers are supported by wooden uprights at each end, and the connecting rods at the sides are also of wood, with ends of steel. The capacity of Messrs. Robinson's largest machine is for logs 60 in. by 30 ft. Driving is effected by belt from a portable steam engine. In some frames even the uprights are of wood, supported at the top by cross pieces. These frames usually carry only a small number of saws, for dividing logs into convenient pieces for transit.



17. UNDER-DRIVEN DEAL FRAME

Portable Frames. The strictly *portable* frames are mounted on trolley wheels, as in **18** (A. Ransome & Co., Ltd.), with shafts and all appliances for hauling. The machines are drawn into an excavation of sufficient depth to allow the horizontal sleepers, on which the log carriages travel, to rest upon the ground; the carriages run upon the rails, which may be continued out to any length desired. Belt driving is adopted, working a central crank, connected to the crosshead of the saw gate. The feed is derived from an eccentric or slotted disc on the face of one flywheel working up by a rod to the silent V wheel, this being a method often followed instead of getting the movements from the saw frame itself. Four sizes of these machines are made by Messrs. Ransome, taking logs from 14 in. to 30 in. square, the entire machine weighing three tons in one case, and seven tons in the other.

Double Frames. *Double* log frames have two sets of saws, which operate on two different logs, simultaneously, though at different rates of feed, if necessary. The capacity is thus greatly increased without much increase in space occupied. In what are termed *equilibrium* frames, the two sets of saws are worked up and down by connecting rods attached to cranks at different angles, so that as one frame is rising, the other is going down, thus balancing the irregular forces, and enabling steady running to be obtained without the use of heavy flywheels. Each log is, of course, fed with its own independent feed motion.

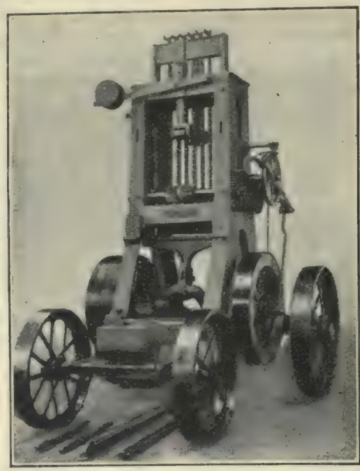
Steam-driven Frames. The steam engine is applied to log frames in a direct manner, by attaching the piston-rod of a cylinder placed on top of the frame to the crosshead of the saw gate to produce the reciprocations. Two advantages accrue from the design; deep foundations are dispensed with, and the machine is independent of belting and other engines, which may be already fully loaded, although at the same time there is steam to spare from the boilers. A steadying effect is obtained by carrying connecting rods down from the saw frame to cranks on a flywheel shaft just below the feed rollers, this shaft also operating an eccentric to work the cylinder valve. Sometimes one of the flywheels is turned to receive a belt, driving on to the pulley of a separate circular saw for resawing the product of the log frame.

A special type of machine which is useful under certain circumstances has a narrow frame for sawing flitches, and an outer projecting blade carrying a single saw for squaring logs, or cutting boards from them, while fed past on a carriage. It is used chiefly in cases where the amount of work done is small, or the power limited.

The rates of feed employed on log frames vary from 6 in. to 5 ft. per minute, with quick return. The travel of the saw teeth ranges from 450 ft. to 800 ft. per minute. The output, of course, varies enormously, according to the class of timber, its condition, and the condition of the saws.

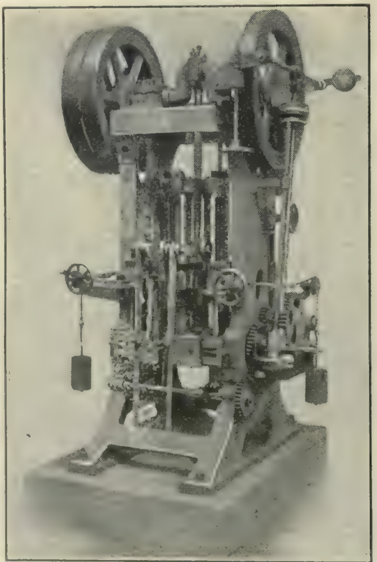
Deal and Flitch Frames. The deal and flitch frames are constructed for resawing deals and flitches *broken out* from logs in the log frames. They bear some resemblances to the latter, especially in methods of driving, but the feeding arrangements are modified, chiefly because the deals

are not irregularly-shaped like logs. The double principle is also carried out more frequently, for sawing two deals at once, and even then the frames are narrow by comparison with those for logs, as the deals are sawn edge-ways up. Overhead-driven and under-driven frames are employed, as in log machines. The timbers are fed through the machines by fluted rollers, which are pressed on the underside and top of the deals as well as at the sides. These side rollers are carried on swings to automatically take up any unevenness in the thickness of the deals. The frames are arranged to take four or five saws per inch in width, as against the coarser pitching in log frames, of one per inch, or thereabouts. Speeds are higher than for log sawing, ranging from 600 ft. to 900 ft. a minute, and feeds up to 8 ft. per minute.



18. PORTABLE LOG FRAME

Equilibrium Deal Frame. Figure **17** illustrates an under-driven deal frame of the equilibrium type, by Messrs. Thomas Robinson & Son, Ltd. The timber is fed through the frame by horizontal and vertical fluted rolls, positively driven, and the back of the wood runs against fences in which a number of little smooth rollers are laid, to form an anti-frictional contact. The fences are provided with means of lateral adjustment for setting the deals without altering the position of the saw blades. Pressure is applied upon the top of the timbers by smooth rollers fixed in pivoted levers which are adjustable. In the machine under consideration we have an entirely different method of getting the feed—by friction between a small leather-covered roller pressed against the face of one crank disc, the effect of which is to rotate the roller and its shaft, going up to a worm and wheel connected to the trains that drive the feed rolls. A hand wheel operating a screw on a spindle lying parallel with the shaft enables the attendant to vary the position of the roll across the face of the crank disc and so to produce faster or slower rates, as the roll is nearer to or farther from the centre of rotation. This drive is not quite so powerful as the silent ratchet, but it admits of instant variation to suit the work being done without stopping the machine. [The principle of the friction feed has been described on page 962, and illustrated in **116**, page 963.] Several standards fitted with rollers are provided to support the timber as it passes along, a regular carriage being unnecessary, the surfaces of the deals being regular, unlike those of logs.



19. OVERHEAD-DRIVEN DEAL FRAME

Double Deal Frames. An overhead-driven frame, by the same makers, is shown in **19**, the operation being like that of the log frame in **9**. with fast and loose pulleys. The connecting-rod is fixed to the saw frame, and is flanked by the two sets of blades. Although this is a double frame, it is not of the equilibrium type, there being only one connecting rod. The feed is of the friction style, but as the driving wheels are at the top of the machine, the roller has to work from the face of one of them, with the result that the feed shaft is inverted.

The double feed frames are usually preferred on account of their greater output, the single ones being employed in sawmills where there is not a sufficient volume of work to keep a double frame properly occupied. The speeds of frames range up to as high as 360 revolutions in the equilibrium types, but these high speeds are not possible when the frames are worked from a single-throw crank-shaft.

The reason for combining deal sawing apparatus with a log frame, as mentioned in connection with two of the log frames previously described, is that many users have insufficient work to warrant the installation of both a log frame and a deal frame.

The combination machine, therefore, meets cases of this kind. After a number of logs have been broken down into deals and flitches, the deal sawing apparatus can be set up, and boards can then be cut.

Although the majority of deal frames are fitted with roller feed, a few are made with rack feed, of a similar character to that of log frames, their principal value being for driving hard or irregularly-sawn woods.

The foundations for these frame saws are necessarily constructed in a solid and unyielding fashion, to withstand the shock of the rapid reciprocations. Masonry or concrete supports are placed under the bases, and the floor of the sawmill has no direct connection with these foundations, but simply serves as a staging by the use of which the timber may be handled and moved about.

Continued

NATURAL DYESTUFFS

Nature's Colourings Still Used in Industrial Dyeing. The Revolution of Artificial Dyes

Group 28
DYEING
3

Continued from page 5782

By HERBERT ROBSON

Logwood. This dyewood has withstood the attack of the artificial dyestuffs better than any of the natural dyes on account of its cheapness, comparative ease of application, and its excellent qualities of fastness to light, washing, and acids. It is not fast to rubbing, however. Coal-tar colour-makers periodically announce the advent of a perfect substitute, but the question of price keeps logwood on its throne as the most important of dyestuffs for cheap blacks. Probably some of the modern sulphur blacks are its severest competitors. Logwood is the wood of a tree known as *Hœmatoxylon campechianium.* The best quality was formerly grown in the Bay of Campeachy, and the French still call it Campeachy wood, but we get our supplies mainly from Honduras and the West Indian islands, and Jamaica logwood is now considered the best. Logwood contains a yellowish-white crystalline body called *hœmatoxylin,* which oxidises in the air and takes a high colour. It is then known as *hœmatin,* the actual colouring principle of the wood.

Logwood reaches England in large logs, and these are converted into chips, plentifully sprinkled with water and exposed to the air. The temperature and the state of the weather has a great influence on the wood during this process of "ageing," and it requires experience. In unskilled hands the wood may be over oxidised and the colour lost. This has brought logwood extracts into favour and in particular hæmatin, procurable in liquid, powder, or crystals. These are dearer, however, than the wood, which must still be used for many purposes.

Logwood is dyed in the usual manner employed for mordant colours. The material may be dyed first and then mordanted, a method sometimes preferred by the wool dyer, but it is usually mordanted and then dyed. The one-bath method, using dye and mordant together, is sometimes used but causes a waste of dye, and for the same reason—that is, the precipitation of the dye in the bath—the colour is liable to rub off the goods. Even when cotton or wool are first mordanted and then dyed there is still loose colour on the fibre, and to fix this the goods are mordanted again after dyeing—a process which is called *saddening.*

Dyeing Cotton. Logwood is used almost exclusively for full, bloomy blacks on cotton, rarely for greys. An iron mordant is used, fixed with tannin. The modern practice hardly differs from that followed in the days before the aniline dyes, and the following old and approved recipe is little varied from.

Full Black on 20-lb. Cotton. To a vat of cold water add 5 lb. of sumach, enter the goods, give a few turns and leave all night, then pass through lime-water; add to this 2 lb. of copperas solution and a pailful of the old sumach liquor; enter, and give six turns; wring out; enter the lime vat again, and give two pails more lime liquor; then scald 6 lb. of logwood and 1 lb. of fustic, add this to another vat of water, enter, and give 10 turns, lift, and sadden with a little copperas, in the same liquor, and soap.

Sumach extract is now used in a hot solution, and a proportionate amount of logwood and fustic extracts are employed. For the best class of goods "nitrate of iron" (ferric sulphate) or acetate of iron is used instead of the copperas. A very ordinary method with cotton cloth is to pad the goods in acetate of iron, dry, pass through lime-water, and dye in logwood extract. Another largely used process is to use sulphate of copper as the mordant. Formerly, the best purple that could be dyed was got with logwood, and this is still used occasionally.

Fast Purple on 20-lb. Cotton. Give a blue bottom in the copperas vat, then a few turns in cold water, with a little stannous chloride at 2° Tw. In another vat add 4 lb. or 5 lb. of logwood previously spent, enter and give eight turns.

Lavender shades are dyed in the same way with less logwood, and light blues are dyed in the copperas vat. Chrome may be used as the mordant in black dyeing, but the result is not so good as with iron.

Dyeing Wool. As lately as 1890, Hummel asserted that "logwood is the essential basis of all good blacks on wool." The mordants are generally either copperas or chrome. The latter is now the favourite, but it makes the wool harsher than copperas, and liable to take a greenish cast if the chroming is not uniformly done.

Copperas Black. Two methods are adopted, the latter being the more usual. For 100 lb. goods, mordant with 5 lb. ferrous sulphate for 1½ hours, adding 2 lb. copper sulphate, 2 lb. alum, and 10 lb. argol to the bath. Lift, squeeze, and let the goods lie over night. Then dye with 50 lb. logwood at the boil. The result is a bluish black; add about 2 lb. of fustic to the bath.

Or, for the same quantity of wool, boil it for 1½ hours with 50 lb. logwood and 5 lb. fustic; lift, cool, add 5 lb. ferrous sulphate and 2 lb. copper sulphate; re-enter, bring to the boil in three-quarters of an hour, and boil for half an hour.

A well-known black, invented by a Lille chemist and sold as Bonsor's Patent Direct Black, is a logwood preparation obtained by precipitating logwood decoction with copperas and copper sulphate. It is rendered soluble by the addition of oxalic acid, and used in a single bath, fustic being added to tone the shade.

Chrome Black. The wool is mordanted as usual with chrome — that is to say, with 3 lb. bichromate of potash and 1 lb. sulphuric acid to 100 lb. of goods. The dyeing is done at the boil, with 50 lb. of logwood, the shade being toned as before with fustic. Where yarn has to stand milling with white yarn it is saddened, as already noted. A direct black may be made similar to Bonsor's by precipitating the logwood with the chrome, the lake thus obtained being dissolved with oxalic acid for use.

Wool is frequently given a light bottom in the indigo vat, and dyed either a copperas or a chrome black. These are called *woaded black.*

Dyeing Silk. Logwood is largely used for silk, exclusively for black. The silk dyer weights the silk in the operation, and as the process is long

and intricate, and varies with each description of silk, it does not come within the scope of this work.

Cutch and Gambier. These closely allied dyestuffs are still largely used by the dyer, and will probably be able to compete with the artificial dyestuffs for many years to come. Bombay cutch, or catechu, is considered the best quality, and is obtained from the species of *Areca.* Bengal cutch, containing more tannin but less colouring matter, is obtained from species of *Acacia* and *Mimosa.* Gambier, sometimes called cube or yellow cutch, is obtained from a Batavian shrub, *Uncaria catechu.* Formerly, it was thought that these dyestuffs were earthy matter, and they were called *terra Japonica,* Japanese earth. Gambier was looked upon as merely an inferior quality of cutch, but the main difference seems to be that it is less oxidisable, and an article on the market known as *patent cutch* is prepared from gambier by adding oxidising agents.

Cutch and gambier have been classed as tannins, and, as a matter of fact, they contain about 60 per cent. of tannin to 8 per cent. of colouring matter. This colour puts cutch and gambier out of the question for mordanting cotton, but gambier in particular is used largely in tanning. The reactions of cutch with the various mordants is very varied, and it is used for a variety of compound shades, especially browns, drabs, and fawns, which are very permanent. The quality of the dyestuff is usually gauged by the extent of its solubility in cold water. Gambier is almost insoluble, but dissolves readily in hot water.

DYEING COTTON. An old recipe says: *Brown on 20 lb. cotton.* Spend 6 lb. of cutch with 6 oz. of sulphate of copper in boiling water. Turn the cotton over in this bath for about 15 minutes. Enter another bath made up with bichromate of potash at the boil. Repeat the baths until the cotton is dark enough. This is nearly the modern practice, except that the cotton is allowed to lie for some hours before entering into the bichrome bath. Cutch and gambier are largely used, together with other natural colouring matters and with artificial dyes, to produce compound shades.

DYEING WOOL. Wool is dyed like cotton, but cutch is not a favourite with the wool dyer, as it gives the material a harsh handle.

DYEING SILK. Gambier is largely used in silk dyeing, as it acts as a weighting material as well as a dye, and resists the soap baths, which cutch does not. As long as weighted silks can find a market, gambier will be most important weighting material to the silk dyer, as he can use as much as 200 per cent. in the bath.

Madder. Madder is the root of the *Rubia tinctorum,* a plant indigenous in Asia but long cultivated in Europe, and in the seventeenth century the attempt was made to grow it in England. Before the days of the artificial dyes it was looked upon as the most important colouring matter for the calico printer. In dyeing, it was used to produce the brilliant Turkey red on cotton by a long, difficult, and even dangerous process. In this use it is now supplanted by alizarin.

Madder still finds a limited use in wool dyeing, generally together with other natural colouring matters, to produce very fast drabs, especially on thick felted material, such as hat bodies, on account of its penetrative power, which is not possessed by its substitutes. Madder gives a wide range of shades with the various metallic mordants.

Both the colouring principles of madder, alizarin and purpurin, are produced synthetically at a much lower cost than an equivalent quantity of natural madder, and the ease of application is altogether in their favour. Madder, however, contains also a brown colouring matter that is absorbed by wool.

Its great penetration makes it serviceable for dyeing thick felts—hat bodies, for instance. Even for this limited use, madder is less and less employed, as certain substitutes have been found, such as the cloth reds sent out by several firms, which give perfectly satisfactory results. These, moreover, can be combined with fustic or logwood in a similar manner to madder. For instance, a cheap brown, very fast to light and milling, is got with Clayton Cloth Red (Clayton Aniline Company), fustic, and sumach, in a single bath. The woollen is boiled with the dyestuffs for 1 hour to 1½ hours; the material is lifted, copper sulphate is added to the bath, and the cloth is re-entered and boiled for half to three-quarters of an hour.

The Redwoods. These are divided into two categories—the *close* or *hard* woods, such as camwood, barwood, and sandal, also called sanders or saunders-wood, and the woods in which the colour is much more soluble, obtained from several species of *Cæsalpinia.* These have a strong family likeness, and are termed indiscriminately Brazil wood or peachwood in the dyehouse. Peachwood has nothing to do with the peach-tree; it is so called because it was imported from Campeachy.

Insoluble Redwoods. The two categories are known as insoluble and soluble redwoods, although the first term is not correct; the hard woods are soluble slowly and with difficulty.

Mahogany is closely allied to these woods, and used to be employed for very fast drabs on cotton. The writer has seen a pattern prepared for the instruction of students, but the colouring matter is too weak for practical use.

Camwood is the strongest and most serviceable, and the shades it gives are very permanent. It is also comparatively soluble.

Barwood resembles camwood, but it is practically insoluble in cold water, and boiling water parts with much of the colour it takes up when allowed to cool. The method of dyeing on wool is to *stuff*—that is, to boil in contact with the wood in a state of sawdust; the particles of wood must mix with the fibre—and to after-treat or *sadden* with the mordant. This is the usual process with the other insoluble redwoods.

Sandalwood is very similar to barwood in its properties, but the solution smells like orris, whereas the barwood concoction is odourless. These woods cannot be used on silk, the method of dyeing proscribing it. Barwood red on cotton was known as *mock Turkey red,* but the alizarins have driven this out of the field. These woods are chiefly used now for compound shades on wool obtained by using them with logwood and fustic.

The Soluble Redwoods. Brazil is said to have obtained its name from its flame coloured forests (*brasas,* a glowing fire) but the "brazil woods" now come from many parts of the world.

Brazil wood was a Government monopoly at one time, and was hence called by the Portuguese, *queen-wood.* The Brazilian supply near the coast was used up, and although it was grown in abundance in the West Indies the demand for it was so great that the supply was quickly and extravagantly exhausted. There is probably very little Brazil wood properly so called on the market.

Pernambuco, Lima wood, Sapan wood, Peach wood, which is also called *Nicaragua wood* or *Santa Martha wood,* and *Jamaica wood* all contain the same

colouring matter, *brazilin*, in varying qualities. They are used to some extent in silk dyeing, giving shades, however, inferior to those obtained with cochineal. They are principally used on alum-mordanted wool to get bright crimsons, and to dye purples on a chrome mordant.

Fustic. This is wood of the *Morus tinctoria*, grown principally in Brazil and the West Indies. It is known also as old fustic, Cuba wood, and yellow Brazil wood. Fustic is not used in cotton dyeing, only for compound shades on silk with other dyestuffs. It is principally used as an extract procurable in red or yellow shades, and for heavy woollens. It is the most important of the natural yellow dyes. On a chrome mordant it gives the pretty shade known as *old gold*. The brightest and fastest yellows are got with stannous chloride as a mordant. It is used principally, however, for compound shades, as the yellows are not very permanent. With copper sulphate it gives olive shades, and the dyeing can be done in a single bath. Dark olives are got with ferrous sulphate as a mordant, and the single-bath method gives good results.

Fustet, or Young Fustic. This is the wood of a species of sumach, *Rhus cotinus*, and was formerly called *Venetian sumach* by English dyers. The French dyers first called it *fustet* or *fustock*, and as the names fustet and fustic were easily confounded "young" was added as a qualification, although fustet has no relationship to old fustic. It was never, we believe, used for cotton, and the yellows and oranges it gives on wool are very fugitive. Hummel in 1885 said that "it would be no great loss if it disappeared from the market altogether," and it is now almost obsolete.

Bark, or Quercitron. This is the inner bark of an oak, *Quercus nigra*, indigenous in North America. Dr. Bancroft first introduced it into England, and in 1786 obtained a monopoly from Parliament giving him the sole right of importing it. The decoction has a yellow orange colour, and must be used fresh. It is sold also in the form of extract. It contains a large percentage of tannin, and was formerly used for dyeing cotton yellow. It is now principally used in calico printing.

Flavine is a preparation of quercitron bark imported from America as a fine light dun-coloured powder. It is stronger and gives brighter shades than bark, and has almost superseded quercitron in the dye-house. Its principal use is on wool to give bright orange shades on a tin mordant.

Persian Berries. These are the unripe fruit of various species of *Rhamnus*, a plant growing in the Levant. They are usually bought as extract or as "Rhamnine," as the berries vary in quality. Their price prevents them competing with the artificial yellows, and they are not used in cotton or silk dyeing. They are employed principally in textile printing, but also, with a copper mordant, on light woollens to get an olive with excellent properties of fastness to light.

Annatto. This dyestuff, sometimes written *annotta* or *arnotto*, is obtained from the pulp enclosing the seeds of the *Bixa orellana*. Its importance in England largely depends upon the necessity of imparting to butter the "natural" colour which the British public expect to find. It is still used in silk dyeing, however, for orange shades in a soap bath, no mordant being required, and for compound shades with indigo, logwood, and other natural dyestuffs. An old time favourite known as *Scott's nankeen dye* was simply a solution of annatto and pearlash in water. Annatto is very largely used in India in silk dyeing, alone and in combination with a native dyestuff, *Kamala*, a reddish bloom on the fruit of the *Rottlera tinctoria*. This gives a most beautiful bright orange.

Weld, or Wold. This plant, *Reseda luteola*, a species of mignonette, is extensively grown in France, and comes on the market as a dyestuff in small dried bundles of stems. The more slender these are the better the quality. With alum it gives the fastest and purest yellow shades on wool procurable with a natural dyestuff, but it is weak in colouring power, and this greatly limits its use. The green known as "carriage green" is produced by topping indigo-dyed cloth with weld. Weld is the most important natural yellow for silk as the colours are fairly fast to light and soaping. The yellows on cotton obtained with weld are of no value, but it has been used for olives on a chrome mordant.

Safflower. This is the dried florets of a species of *Carthamus*. It contains a red dye and a worthless yellow colouring matter. According to Charles O'Neill "it yields the most delicate shades that the art of the dyer can produce." It has also the distinction of being the only dye formerly used for legal "red tape." It yields very fugitive shades, however, and is now hardly employed. The method of dyeing silk was very curious. If dyed direct with the safflower the silk takes up yellow, and a poor brick-red shade is obtained. To dye silk, cotton yarn was first dyed with the safflower, only the red going on the fibre; the little yellow taken up was very easily washed out. The red was then extracted in a weak solution of carbonate of soda, and used to dye the silk. In both silk and cotton dyeing it is almost superseded by safranine, an artificial dyestuff.

Turmeric. This is the rhizomes of various species of *Curcuma*. They resemble ginger, and are put on the market in the state of powder. It is a substantive colour going on to all fibres direct; in fact, no mordant has been found for it, and it produces very fugitive shades. It finds a limited use, however, in mixture with some of the natural dyestuffs and with the acid colours on wool. It is occasionally used alone for oranges and yellows on silk.

Orchil and Cudbear. A species of lichen known as *Rocella*, found in great abundance in the Canaries and the Cape de Verde Islands, gives a colouring matter sold as a paste under the name of orchil or archil, or as a red powder called cudbear. A dry paste used to be prepared, and sold as *persis*. Several preparations known as *orchil carmine*, *fast orchil*, and *French purple* are made, but are almost obsolete. Cudbear gives a bright bluish red on silk, and is still used. On wool it is simply applied without mordant in a slightly acid bath and gives depth and richer tint to reds dyed with safflower and cochineal. The shades are not very permanent, and these lichen colouring matters are largely superseded.

Cochineal. Cochineal is a small female insect, the *coccus cacti*. It was thought to be the grain or berry of a plant, and the tints produced with it are still sometimes called "grain colours." It gives the finest procurable shades of crimson, red, purple, and scarlet on wool and silk, but it has been largely superseded by the azo dyes, and by far the greater portion of the cochineal imported into England goes to the confectioner. The colouring matter, carmine, or carminic acid, is extracted from it on a large scale in France, and is used for colouring

artificial flowers. Its principal use in England has in recent years been for Army cloths, but even in this capacity it has felt very seriously the competition of khaki. With a mordant of tin salts it gives a scarlet, and with alum a crimson on wool, and these are practically the only uses to which it is now put. The scarlet is toned by the addition of a little yellow dye, usually flavine or fustic. Crimson and scarlet were formerly dyed on the same mordants on silk, but the shades are not very fast to light, and the azo dyes are almost exclusively used.

Kermes. This is the dried bodies of another species of the coccus insect, and the colouring matter is identical with that of cochineal. It is very much weaker in colouring power, and even before the days of the artificial dyes it was little used in England.

Artificial Dyestuffs. Although the dyer's art is prehistoric, he has been dependent until half a century ago entirely upon natural colouring matters, and of these comparatively few only of the immense variety provided by the animal and vegetable realms have been used in dyeing. The reason is that the natural dye in some cases depends for its existence on the life of the plant or animal whose vital processes have produced it, in others that it resists every attempt to extract it, or that when extracted it is too fugitive and unstable on textile fabrics to be of any service. Although some of the usable natural dyestuffs are of an excellence hardly yet surpassed in some directions by artificial products, as a rule these latter are much simpler in use, a matter of first importance to the dyer. Hence, short as the life of the artificial dyestuffs has been, they have driven the majority of their predecessors from the field they have occupied alone for so many centuries, or at least have greatly restricted the scope of their utility. Being definite substances, and therefore always possessing the same properties, they are simpler and more certain in their application than the natural dyes.

Although of such recent origin the manufacture of artificial dyes has developed at a rate probably unparalleled in the history of industry, and we now see gigantic businesses—which will compare in dimensions with any others in the world, of whatever kind—making a class of compounds of which fifty years ago there was hardly a single representative and certainly not one in current use as a dye. It would probably be a safe assertion if we were to say that the number of patents taken out for coal-tar products exceeds that obtained for any other class of inventions.

History of the Artificial Dyestuffs. The first artificial colouring matter not a pigment was picric acid, discovered in 1771 by Wolff, who made it by treating indigo with nitric acid. He named it from its taste (Greek *pikros*, bitter), and recommended it as a yellow dye for silk. The real start of the artificial dye industry began with the invention of coal gas and the consequent attempts to utilise coal-tar obtained as a by-product. Years passed, however, before much was done. Runge made rosolic acid about 1833, and Charles Lowe, of Manchester, obtained phenol and picric acid from coal-tar in 1855 and was the first to do so.

Then came the first real step. In April, 1856, William Henry Perkin, who, happily, is still living, made a substantive dye for silk known as Perkin's Mauve. He was trying to synthesise quinine by oxidising aromatic bases. He found that the bluish precipitate produced by the interaction of aniline and bichromate yielded a splendid violet solution with alcohol, and the dye was obtained by evaporating the tincture. The result was British patent 1984 of 1856, taken out after consultation with Pullar, the Perth dyer. The establishment of the first aniline colour factory soon followed. Perkin and Sons erected a factory at Greenford Green in 1857, and began to put Perkin's Mauve upon the market in the following year. Aniline was thus the first coal-tar product which yielded a commercially useful dye. Perkin, now Sir William H. Perkin, F.R.S., was a youth of eighteen at the time and went into partnership with his father and brother.

Aniline had been known for some time. It was first prepared in 1826 by Unverdorben, who obtained it by the dry distillation of indigo, hence the name, one of the well-known species of the indigo plant being *Indigofera anil*. Unverdorben called it *krystallin*. The first to find aniline in coal-tar was Runge, in 1834. He called it *kyanol*. For a long time it was obtained in a mixture with homologues, especially toluidine. For this reason no two aniline makers sold the same thing, nor was there any confidence to be placed in getting the same aniline twice from the same firm. In 1840 Mitscherlich first discovered nitrobenzol and both Zinin and Hofmann made aniline from it. The commercial process now used in making aniline—that is, the reduction of nitrobenzol by nascent hydrogen—was discovered by Bechamp in 1854, when the price of aniline fell at once to seven shillings a pound.

Perkin's dye was first sold in this country by the name of Tyrian Purple, but on the Continent it was called Perkin's Violet or Mauveine. It was largely used for silk for sunshades and is still used for paper for postage stamps.

Perkin's success set chemists at work on coal-tar, and since his discovery many thousands of coal-tar dyes have seen the light. The next discovery was Magenta, obtained by Verguin in 1859 by acting on aniline with stannic chloride, and in the same year the second artificial dye factory was erected by Geigy and Co. at Basle. The French patent law of 1844, protecting substances and the processes by which they are prepared, prevented much being done in France. Hence, when Durand and Gerbert Keller introduced the use of mercury salts in the preparation of Magenta, they, too, went to Basle.

In 1860 Magenta was £30 a pound, and this and Mauve were the only artificial dyes at that time made from coal-tar. In that year, however, Azuline, the first coal-tar blue, was discovered, and the method of preparing Magenta by oxidising a mixture of aniline and toluidine with arsenic acid was invented by Medlock, and brought the dye into commercial use.

Two important events mark the 'sixties, the discovery of aniline black by Lightfoot, in 1863, and the synthesis of alizarin, one of the colouring matters of madder, by Graebe and Liebermann in 1868, both epoch-marking achievements. Graebe and Liebermann thus effected the first synthesis of a natural dyestuff. Their process was not, however, a commercial one, but Caro and Perkin soon introduced the sulphonating process still employed. A large number of new dyes was soon added to the small list then existing, and the new industry was fairly launched. The further history of the subject will be touched upon later.

Continued

STEAM ENGINE CONSTRUCTION

Willans Engines. Horizontal Engines. Bored Guides. Semi-girder Engines. Long-stroke Engines. Tandem Engines

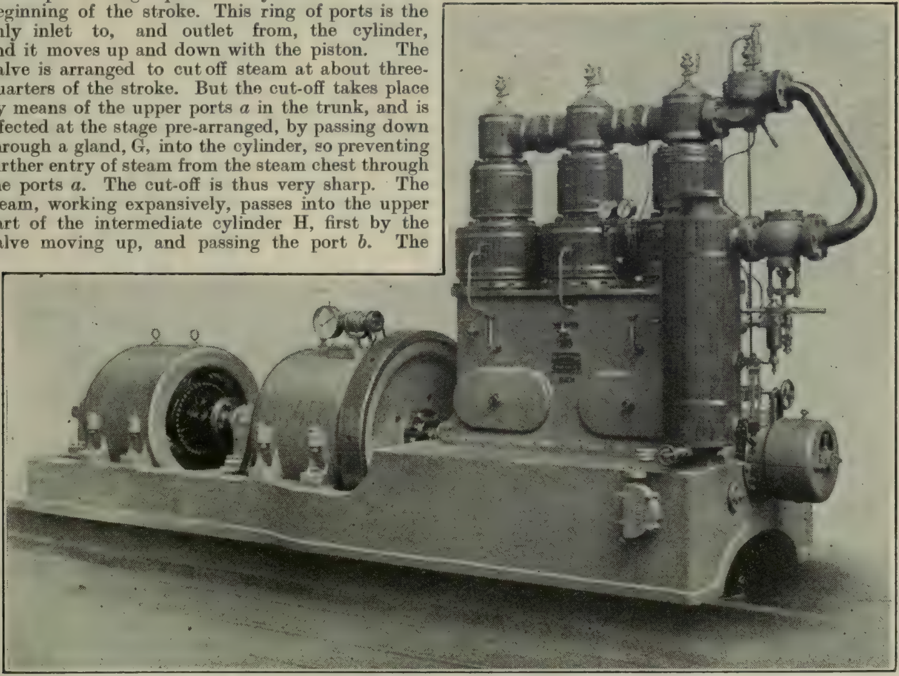
Group 24
PRIME MOVERS
4

Continued from page 5751

By JOSEPH G. HORNER

AMONG the high-speed vertical engines the Willans [23] occupies a leading position. It was among the earliest to provide a direct unbelted drive to dynamos. The name by which it is best known, the *central valve engine,* indicates its leading feature. It might be considered a form of trunk engine in which the piston rod forms the trunk, enclosing the piston valves which control the steam supply to the cylinders. It is also a *single-acting* or *constant-thrust* engine. Figure **24** shows a triple expansion type in external view, lagged, and in vertical section. It is driving a dynamo. It is a 100-horse-power engine, making 380 revolutions per minute, and was built for Birmingham University.

Action of Engine. The action of the engine is as follows. Steam is brought into the steam chest above. Its supply is regulated by a governor (not shown) which controls, through the rod A, the opening of the throttle valve B. The steam enters the upper piston rod or trunk C, through the cut-off ports *a*, seen near the top of the rod. The line of piston valves, D, working inside the piston rod, is operated by the eccentric E on the crank pin. The ring of ports, *b*, is thus opened at the proper moment, allowing the steam to pass into the top or high-pressure cylinder F at the beginning of the stroke. This ring of ports is the only inlet to, and outlet from, the cylinder, and it moves up and down with the piston. The valve is arranged to cut off steam at about three-quarters of the stroke. But the cut-off takes place by means of the upper ports *a* in the trunk, and is effected at the stage pre-arranged, by passing down through a gland, G, into the cylinder, so preventing further entry of steam from the steam chest through the ports *a*. The cut-off is thus very sharp. The steam, working expansively, passes into the upper part of the intermediate cylinder H, first by the valve moving up, and passing the port *b*. The expanded steam then passes through openings, *c*, to the lower side of the piston, and to the upper side of the piston of the intermediate cylinder. The lower part of the high-pressure cylinder is thus for the time being a receiver or steam chest to the intermediate cylinder. It will also be noted that there is no upward pressure, because during the upward movement the steam only passes from the upper to the lower side of the piston. During the second stroke, which, of course, begins the second revolution, the steam passes into the intermediate cylinder, pressing on top of its piston. It again enters the piston rod by a ring of holes, *d*, and passes thence into the cylinder by a ring of ports, *e*. It is then cut off by the ports above, *d*, and passes down through the gland of that cylinder into the lower portion, which is also the steam chest for the last, or low-pressure cylinder, in which a third cycle takes place. At the final stage the expanded steam passes from the bottom of the low-pressure cylinder through the exhaust chamber to the condenser. Thus we have the interesting design of two sets of triple expansion engines arranged in tandem, and each set driving to the same crank shaft. Also the engines can be converted from simple to compound,



23. CENTRAL VALVE TRIPLE EXPANSION ENGINE 180-H.P. DIRECT COUPLED TO GENERATOR

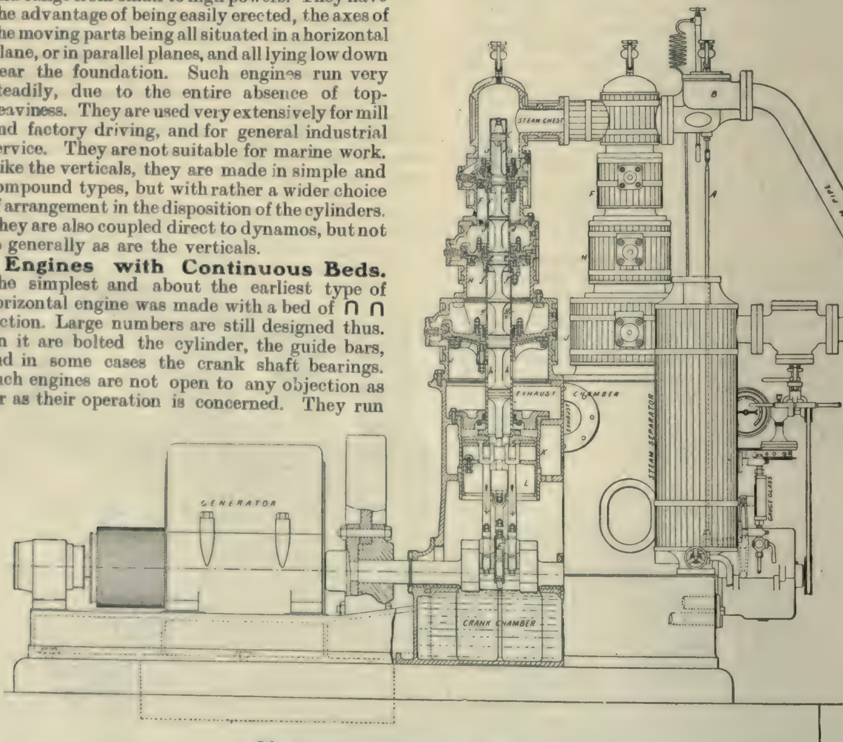
or to triple expansion by the simple addition of suitable cylinders and valves.

Since there is no upward pressure, knocking of brasses and joints would occur if provision were not made to prevent it. This provision takes the form of an air cylinder, K, and guide piston, L, to the top of which the cylinder pistons are bolted. The guide piston is driven with connecting rods, one on each side of the eccentrics E. The top of the guide cylinder is closed, and on the up stroke the air is compressed, so cushioning the piston and the parts attached to it. Some power is thus stored up and given out again on the down stroke. A result is that the reciprocating parts always press downwards, and the connecting rod brass is always pressed against the crank pin, and the crank shaft against the lower main bearing brass. Hence there is no knocking or back lash. The lower part of the framing is formed into an oil chamber, and the cranks and parts adjacent are lubricated by the splash of the cranks. The entire chamber is closed in, and has doors. The *steam separator* at the side mechanically removes the particles of water from the steam.

Horizontal Engines. These exist in even larger variations in design than the vertical. They are of both non-condensing and condensing types, and range from small to high powers. They have the advantage of being easily erected, the axes of the moving parts being all situated in a horizontal plane, or in parallel planes, and all lying low down near the foundation. Such engines run very steadily, due to the entire absence of top-heaviness. They are used very extensively for mill and factory driving, and for general industrial service. They are not suitable for marine work. Like the verticals, they are made in simple and compound types, but with rather a wider choice of arrangement in the disposition of the cylinders. They are also coupled direct to dynamos, but not so generally as are the verticals.

Engines with Continuous Beds. The simplest and about the earliest type of horizontal engine was made with a bed of ∩ ∩ section. Large numbers are still designed thus. On it are bolted the cylinder, the guide bars, and in some cases the crank shaft bearings. Such engines are not open to any objection as far as their operation is concerned. They run well, are durable, and are easily kept in order. Nevertheless, they have been to a great extent superseded by other designs, which are more compact, are more readily erected, and have more graceful outlines.

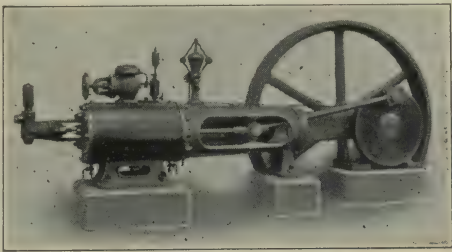
Engines with Bored Guides. The most important element in this change has been the substitution of bored guides [25] cast solidly with the bed, for the loose flat guide bars bolted thereon. These are embodied in numerous engines, which vary much in other respects. The guides are bored, and the end flange is faced at a single setting of the boring bar, or cutter head, and the bearings for the crank shaft are bored at the same height of centre. There is thus no time occupied in adjustment of guide bars to the centre of the cylinder. The cylinder is also in this design set without the trouble of making linear adjustments, being centred by the simple device of turning a shallow shoulder, or *check*, on the cylinder end to fit a corresponding recess within the rear end of the guide. The flange of the cylinder is bolted to a flange on the guide, and this is the only attachment and support afforded to the cylinder, in what is termed the *overhanging cylinder type* of engine [26]. One result of this simplification of design is that the building up or erection of such engines is less expensive than that of those in which numerous adjustments have to be made during erection. A slight incidental advantage in the overhanging type of cylinder engine is that the parts are free to expand longitudinally with heat, which is not the case when the cylinder is bolted down on a bed-plate.



24. WILLANS CENTRAL VALVE ENGINE

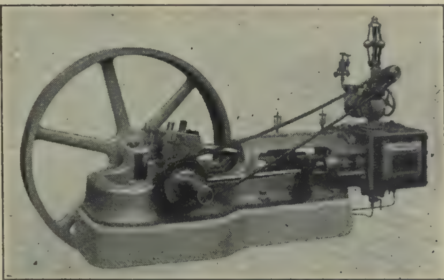
The solid bored guides, however, do not contain provision for taking up wear, as the flat separate guide bars do. But that is of no moment, because means of adjustment is, in the better class of such engines, embodied in the piston rod crosshead, which slides in the guides, this adjustment being in the form of wedge slips. Moreover, the bored surfaces are of such large area that wear takes place very slowly.

Beds with Self-contained Bearings. The design of the bed, apart from that of the guides, is varied extensively. One of the most common is a bed which is extended at the sides laterally [26] to leave room between the crank shaft bearings for the movements of the dip form of crank and the big end of the connecting rod. The opening may be cut right through, and be completely enclosed by the frame, forming a crank pit, or it may take the form of a deep recess unenclosed at the front end. It, and the bearings, may also be disposed symmetrically about the centre, or unequally. The first is preferable generally, because there is no right and left hand arrangement to be considered, and the flywheel and the front driving pulley can be put on either end of the crank shaft.



25. HORIZONTAL ENGINE

Engines of this snug, self-contained type can be employed as *vertical wall engines*, which is hardly practicable in the case of the older types first named. The entire engine can be bolted bodily to a wall, and either the cylinder or the flywheel may be uppermost. Wall engines are employed in factories for driving lengths of shafting, the advantage being that floor area is not then occupied.



26. HORIZONTAL ENGINE
(Marshall Sons & Co., Ltd.)

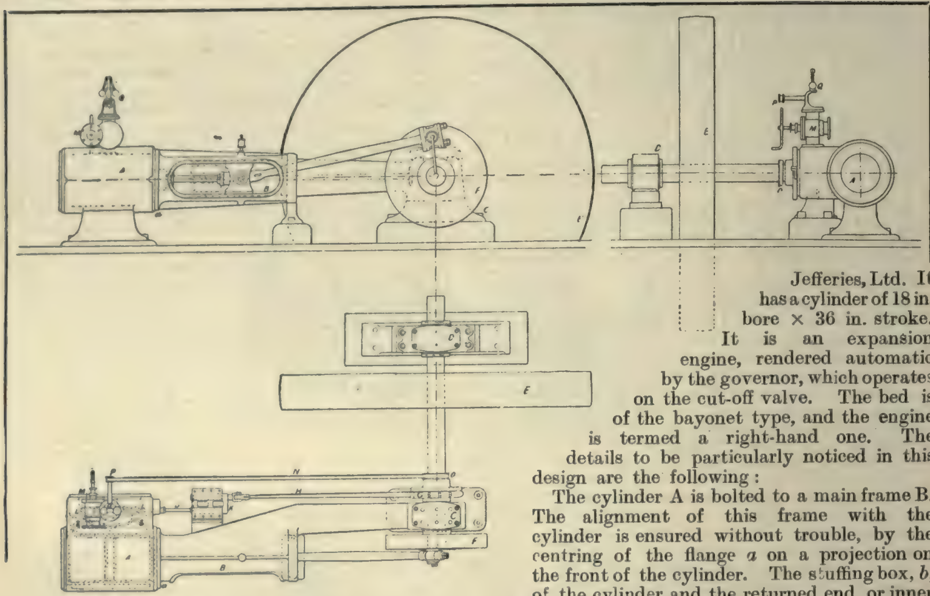
Semi-girder Beds. Another great group of engine frames is termed the *semi-girder* type, and sometimes the *bayonet* engine. Such engines nearly all embody the bored guide, but differ from **26** in the bayonet design, in which the bed is extended to one side of the centre line, as in **25**, and carries a single bearing only. The crank in such designs is of the circular plate, or disc type, and the bed is set back sufficiently far from the centre line to leave room for the *crank disc*. Another independent bearing is necessary in these designs to carry the opposite end of the crank shaft, and the flywheel usually occupies the space between the two bearings. Around this design details vary in the hands of different manufacturers, those shown in **25** being usually embodied in engines of small and medium dimensions. In the larger engines other modifications are generally made.

A few leading points may be noticed, first, in the external view of one of the standard horizontal types of engines, made by Robey & Co., Ltd. [**27**]. It has a semi-girder, or bayonet type of bed. The cylinder A, which has a liner, and is lagged, has its own separate foundation. It is checked into and bolted to the cylindrical cross head guide B, by a flange *a*. The guide has its own foot and is in one casting with the bayonet, which terminates in one of the main bearings C, for the crank shaft, which bearing has its own independent foundation. The other main bearing, D, is independent on its own separate base, and between the two the flywheel E is hung.

To obtain a bearing sufficiently wide or long between the disc crank F and the eccentric G which operates the slide valves involves throwing the eccentric G and its rod H out of line with the valve rod J. A sliding connection, K, is therefore made between the two rods. The steam passages, *bb*, are short, which involves two valves, LL, one for each end. Governing is done through the throttle M, and is effected from a belt, N, passing from a pulley, O on the crank shaft to P, which drives the governor Q through bevel gears. From this skeleton drawing we may now proceed to more detailed engines.

It is usual to class horizontal engines as right or left hand, which signifies that the flywheel is situated to right or left of the longitudinal axis of the engine when the observer is standing facing the engine at the crank shaft end. Thus, **27** is right hand. An engine is said to run outwards when, the observer standing in the same position, the top of the flywheel is rotating in his direction; inward, when running in the direction opposite.

Large Horizontal Engines. In these, though the general resemblance to the semi-girder type is obvious, the increase in dimensions is one reason for differences in methods of construction. Another is that most of these are compound, and many also condensing, engines. A common design is this: Girders of rolled sections are used, with or without composite connections of cast iron, to form the bed plate upon which the engines are carried. In others, the bed plate is abandoned and separate foundation blocks of masonry or concrete receive respectively the several main portions of the engine cylinder, main bearings, etc. The cylinder is a separate casting with a foot for bolting down by. The girder, generally cylindrical, is bolted to the cylinder, thus receiving adequate support at that end, while a foot is cast on it at the end opposite, which is bolted down to a foundation block. Separate castings form the crank shaft bearings, or frequently one of the bearings is cast with a foot, and forms an extension of the guide casting in bayonet fashion. All the parts where the vibration is most intense are thus secured to foundations, while intermediate portions are self-supporting. When such engines are made compound, the cylinders are arranged in line, *tandem*, or side by side. If of condensing design, the condenser is placed behind, and its pumps are worked by a tail rod from the low-pressure cylinder. In such arrangements each cylinder and condenser has its own isolated foundation. But if a rolled girder bed is built it is extended sufficiently far to include the low-pressure cylinder and the condenser. Such engines are mostly of high class design. They generally

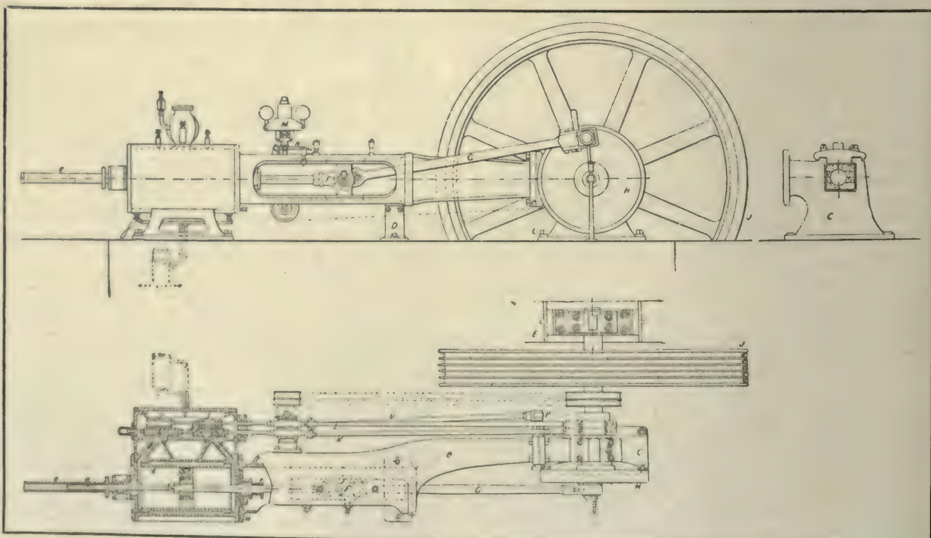


27. SEMI-GIRDER TYPE OF ENGINE
(Robey & Co., Ltd., Lincoln)

include automatic governing from the crank shaft, by which, by various methods, the steam is cut off to work at varying rates of expansion by the valves, so that the variation from normal speed is reduced within almost infinitesimal limits.

Long-stroke Stationary Engines. This is a type of simple engine which is useful for general purposes, as for driving machinery in shops, sawmills, etc. The rate of revolution is not high, 60 per minute being the normal in the engine shown [28], which is one by Ransomes, Sims and Jefferies, Ltd. It has a cylinder of 18 in. bore × 36 in. stroke. It is an expansion engine, rendered automatic by the governor, which operates on the cut-off valve. The bed is of the bayonet type, and the engine is termed a right-hand one. The details to be particularly noticed in this design are the following:

The cylinder A is bolted to a main frame B. The alignment of this frame with the cylinder is ensured without trouble, by the centring of the flange *a* on a projection on the front of the cylinder. The stuffing box, *b*, of the cylinder and the returned end, or inner flanging of the cylinder adjacent thereto, form the front cover, a usual alternative to the regular cover and external flange seen at the tail end. The main frame B is bolted at the end opposite to the cylinder to the main bearing C by the flange *c*. The whole engine is supported by the bearing C, by a separate bearing, D, bolted to the main frame at the termination of the crosshead guide (of cylindrical type), and by the foot bolted to the cylinder which forms the support at the extreme left-hand end. The bearing E is an independent casting, and supports the crank shaft on the side opposite to the fly-wheel.



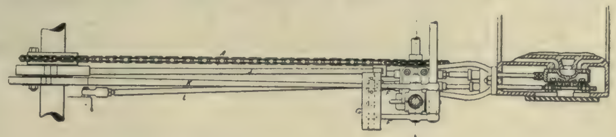
28. LONG-STROKE STATIONARY ENGINE (Ransomes, Sims & Jefferies, Ltd., Ipswich)

The cylinder A is jacketed by the fitting of a loose liner of hard metal. The sectional form of the piston, with the plate screwed down to confine the metallic packing, is shown. In consequence of the long stroke the piston rod and piston are relieved by a tail rod, *d*, protected with a sheath, *e*, extending to the rear through the back cover. The stuffing box for the tail rod is bushed with gunmetal, as are also the stuffing boxes and glands at the front end for the piston and the valve rods.

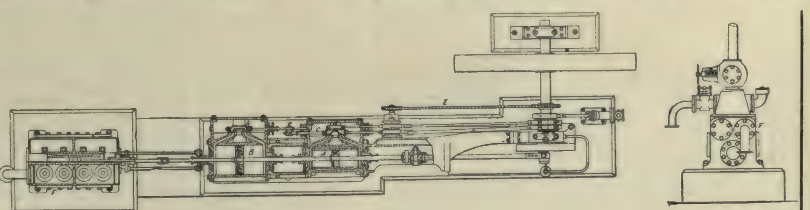
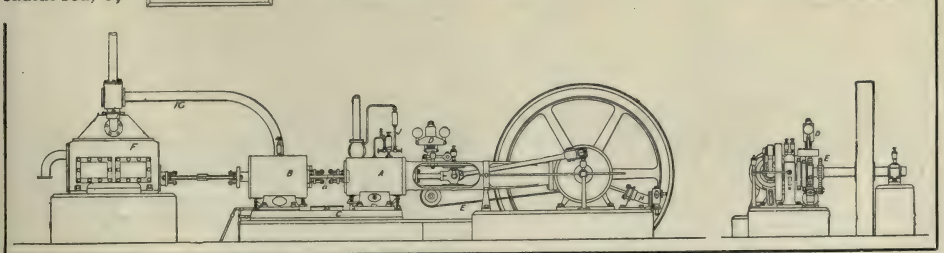
The cross head F moving in the circular guides receives the small end of the connecting rod G, which has provision by a tapered cotter bolt for taking up wear of the brasses. The large end has similar provision made by a tapered cottar. It drives to a crank disc, H, which is believed to run more evenly than a lever form of crank, being in balance. In this, as in many engines, the mass of the large end of the connecting rod is counterbalanced in the disc. The flywheel J is an example of the grooved type for cotton rope driving.

The Valves. Returning to the cylinder end we note an arrangement which is common in long-stroke engines—namely, the use of separate valves for each end, with steam ports, *ff*, and exhaust ports, *gg*. This avoids long steam passages with their consequent waste of steam. The main slide valves, *hh*, have steam passages passing through the body as seen in the sectional view to the right, and the usual exhaust arch. The travel is constant. Expansive working is provided for by the cut-off valves, *jj*, the travel of which is varied, thus cutting off the steam passing through the ports in the main valves. K is the eccentric rod for the main valves, L that for the expansion valves. The movements of the latter are varied by the governor M. In its ascent and descent acting through the lever N it varies the position of the radius link P, the upper end of which is operated by the eccentric rod L, while the lower end is held by a radius rod, O, in the same vertical plane as L. The position of the link in relation to the slide spindle controls the travel of the cut-off valves, and therefore the point of cut-off.

An automatic expansion gear of this type, fitted to a smaller engine, with a single main valve and cut-off valve, is shown in 29. The governor is driven from the crank shaft by a pitch chain A. In the previous figure it is driven by belts and pulleys. The advantage of pitch chain drive is that slip cannot occur as in belts. The chain drives the bevel wheels B C, C being on the govenor spindle. The latter, therefore, is rotated at a speed exactly proportionate to that of the engine. The balls DD, under the operation of centrifugal force, overcome the resistance of the spring E and move the levers FF, the fulcrum of which is at *a*. These levers are connected to a crossbar, G, from which depend the drag links *b b*, by which the radius link H is raised and lowered in relation to the die block in the slide spindle J, actuating the cut-off valve. The cut-off eccentric rod K is brought nearer in line with, or farther from, the slide spindle J as the link is lowered or raised. L is the radius rod, which is connected to the lower end of the link, and is anchored at the end opposite to one of the bearings. The little cylinder M with its piston helps to steady



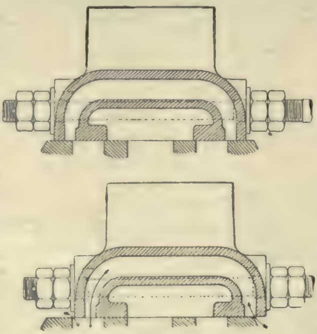

29. GOVERNOR GEAR OF ENGINE (Ransomes, Sims & Jefferies, Ltd., Ipswich)

30 LONG-STROKE TANDEM ENGINE (Ransomes, Sims & Jefferies, Ltd., Ipswich)

the movements of the link. It is carried by a pillar *e* in the governor framing; *d d d* are self-acting lubricators.

Long-stroke Tandem Compound Engine. The next illustration [30] is that of an engine by Ransomes, Sims & Jefferies, Ltd., fitted with a jet condenser. In the figure, A is the high-pressure, and B the low-pressure cylinder. They are both cast with feet, which are bolted to the base plate C, and are rigidly connected in an axial direction by tie-bars *a a* of wrought iron. The steam chests form a portion of the cylinder castings. As there is only one set of ports, the passages are longer than in the last example. The valves are of different types in the two chests. The valve *b* in the low pressure steam chest has constant travel. It is of the *Trick* type, the feature of which is the double opening for steam, which allows a good supply with a short valve travel. It is operated from the rod which moves the main slide valve *c* in the high pressure cylinder; the connection is seen at *e*; *d* is the cut-off valve worked expansively, and this is operated from the governor D. The governor is driven from the crank shaft by pitch chain E. The steam exhausting from the low-pressure cylinder passes into the jet condenser F through the pipe G. The air pump plunger, which is partly seen in the plan view, is operated by an extension of the piston rod, but the valve details are not indicated. The condenser body is bolted to its own foundation, and connected to the low-pressure cylinder with rigid rods. H is a force pump for feeding the boiler, J is a sight feed lubricator over the high pressure cylinder. The general fitting of covers, glands, connecting-rod, etc., may be noticed, and in many respects these are identical with those shown in the previous engine.



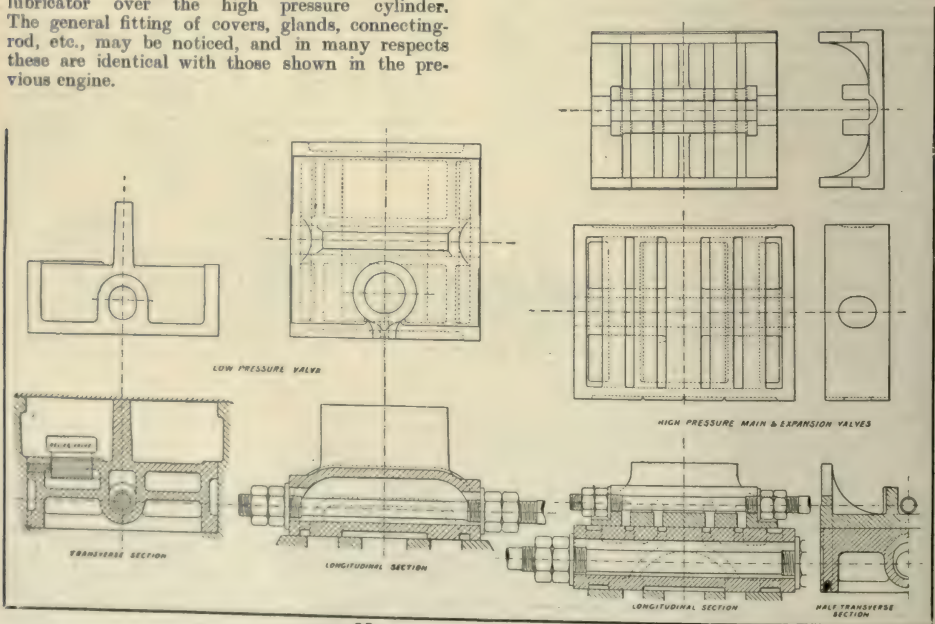
31. TRICK VALVE
(Ransomes, Sims & Jefferies)

The valves, enlarged, are shown in 31, which, if compared with the general drawing will render the details clear. The low pressure *Trick* valve is seen in the group of 32 in end view, in transverse section, in a plan of the back of the valve, and in longitudinal section, in which the valve rod is included. It will be noticed that the latter is secured with nuts and lock nuts at each end. This is a usual method of attachment, because it permits of exact longitudinal adjustment or setting of the valve. The rod does not fit closely in the hole, and the latter is elliptical in shape to allow for the wear of the faces of valve and steam chest.

The valve is shown in middle travel. Steam cannot enter from the chest until the edge of one opening of the steam passage has passed beyond the edge of the steam chest face. Then steam will enter and pass round the passage into the opposite port and also simultaneously outside the edge of the valve, as indicated by the arrows [31]. At the same time steam will be exhausting as shown.

The main and expansion valves for the high-pressure cylinder are shown to the right of 32. Both main and cut off valves are shown in middle travel. The main valve has a moderate amount of steam lap, with a corresponding amount of fixed expansion. The cut-off valve having its movements controlled by the governor, varies the width of the three openings to steam in either end of the main valve. This treble-ported type of valve has a third of the travel required for a single-ported valve of equal total opening.

Continued



32. DETAILS OF VALVES

PETROLEUM

The Source and Nature of Petroleum. Inorganic and Organic Theories. How Petroleum was Formed. The Nature of Petroleum Beds

Continued from page 5767

By Sir BOVERTON REDWOOD

PETROLEUM, a Latin term meaning rock oil, is a general name for a wide variety of kindred mineral substances, ranging from wholly opaque to transparent, from semi-solid to extremely fluid, and from odourless to agreeably aromatic or highly offensive, all combustible, but with very different degrees of inflammability, and only in rare instances fit for use in any way without previous treatment.

The Petroleum Act, 1871 (34 and 35 Vict., ch. 105), which is still in force, except as to the standard of flash-point, and the mode of testing [see Methods of Testing, in subsequent article], defines petroleum in the following words: "For the purposes of this Act the term 'petroleum' includes any rock oil, Rangoon oil, Burmah oil, oil made from petroleum, coal, schist, shale, peat, or other bituminous substance, and any products of petroleum, or any of the above-mentioned oils; and the term 'petroleum to which this Act applies' means such of the petroleum so defined as, when tested in the manner set forth in Schedule I. to this Act, gives off an inflammable vapour at a temperature of less than 100° of Fahrenheit's thermometer." It will thus be seen that the legal definition of petroleum is a wide one, embracing liquid products, such as coal-tar, and the solid product, paraffin, which are not "petroleum" in the commercial acceptation of that term. The reference to Rangoon oil and Burmah oil doubtless had its origin in the circumstance that shortly before the Act was passed the produce of the Burmah oil-fields was in small quantities brought to this country, petroleum having previously been imported only from the United States. The name of Rangoon oil was derived from the port of shipment, "Rangoon oil" and "Burmah oil" being two names for the same product. Petroleum now comes to the United Kingdom from many other countries, and there is less reason for retaining the specific mention of Rangoon oil or Burmah oil than for specifying Russian oil or the oils of Roumania and Borneo.

Crude Petroleum Oils. Crude oils, as collected, invariably consist of mixtures of several allied compounds, with, not infrequently, other substances, either dissolved in them, or mechanically enclosed and retained in suspension. They may be roughly classified as illuminating oils and fuel oils, according to the preponderance of one or other of these distinct groups of compounds in the natural admixtures, or in blends resulting from indiscriminate collection. The crude oils are further divided into asphalt-base and paraffin-base oils, according to the nature of the more solid matter held in solution by the more fluid, and determining the quality and use of the residue left on distilling off the lighter oils. The paraffin-base oils must not, however, be confounded with the ordinary burning oil (kerosene or paraffin oil), as the latter is largely made from asphalt-base crude oil. Petroleum was at one time called coal-oil, partly because a kindred substance could be prepared by distillation from coal, but chiefly from a mistaken idea that, being combustible, it must necessarily be derived in some unexplained way from coal seams. The term fell into disuse when it was found that not only did no such relation exist, but that oil-bearing rocks and coal rarely occur in the same geological series of strata.

The Origin of Petroleum. Much controversy has arisen upon the origin of these various compounds, some contending for their production by purely chemical action, deep in the unknown interior of the earth, and their ascent as vapour to be cooled and reduced to fluid or solid nearer the surface.

The distinguished Russian chemist, Mendéleeff, who has recently passed away, gave the weight of his authority to the view that petroleum is of inorganic origin. The great density of the earth, the well-known presence of iron carbide in meteorites, as well as of iron in the solar system, as shown by the spectroscope, and the presence of iron in basalts and other eruptive rocks, were adduced by him as powerful arguments in favour of the assumption that the interior of the earth contains large amounts of iron, whether combined with carbon or not. Proceeding upon this assumption, he ascribed the formation of petroleum to the action of carbide of iron at high temperatures in the interior of the earth upon water which has penetrated through fissures produced in the earth's crust by the elevation of mountain chains or other changes of structure which have occurred.

On the other hand, the equally illustrious chemist, Berthelot, also recently deceased, accepting the hypothesis that the interior of the earth contains free alkali metals, ascertained by experiment that when carbonic acid or an earthy carbonate acts upon the alkali metals at a high temperature in the presence of water-vapour, chemical changes occur, which result in the production of hydrocarbons similar to those of petroleum, the exact composition of the hydrocarbons varying with the temperature. He therefore expressed the view that petroleum may have been produced by the infiltration of water containing carbonic acid gas into the interior of the earth, where it would be brought into contact with the alkali metals at an elevated temperature, and under great pressure, with the production of both liquid and gaseous petroleum.

Neither of these hypotheses is tenable, in view of the facts of the geological structure and composition of the rock-beds constituting the oil-bearing series in any part of the world.

Theories of Organic Origin. Two other schools exist of disputants on the origin of petroleum, each having amassed a sufficient body of evidence in support of animal origin in one case, of vegetable derivation in the other, to convince its partisans that the view propounded, if not of universal applicability, holds good in at least the great majority of oil-fields. The vast quantities of animal and vegetable remains stored in limestones and clays of various geological periods, and the legitimate assumption that where the rocks are not so rich in fossils their absence is due to want of preservative conditions rather than deficiency of life at the time of formation, indicate an ample supply of organic material at all periods of the

earth's history, as represented by stratified deposits; its decomposition generally, and its conversion into petroleum more rarely, being dependent on the conditions prevalent at the time and place of embedding in the strata, while the subsequent upheavals and removals of vast masses of material (to constitute the newer deposits) would tend to waste much of the earlier-formed oil, traces of which remain as asphalt or other bitumen, even in rocks of extreme antiquity, and in nearly every country in the world. As the adherents of the hypothesis of vegetable origin base their views generally on observations taken in different regions from those referred to by the exponents of animal origin, there is every probability that both schools are right in the main thesis, though wrong in insisting on its universality. The animal remains of the Ohio limestones have produced a different oil from that of the vegetable matter embedded in the somewhat later sandstones of the adjacent State of Pennsylvania. In each region, and for each geological period, the chief or sole factor is to be determined independently, and in many cases both animal and vegetable remains may have been contributory to the same store of petroleum.

Proof of Organic Origin. The most noted exponents of the view that petroleum is solely or mainly of animal origin are Höfer and Engler. In a series of experiments the latter obtained, by the distillation of menhaden (fish) oil at a high temperature and under considerable pressure, a product resembling petroleum. The distillate yielded by fractionation a lighting oil which was described as indistinguishable from commercial kerosene, and this statement the author of these articles, having received a sample of the product many years ago from Professor Engler, is in a position to confirm.

Oil is still being formed in various parts of the world, in some places from animal, in others from vegetable remains, though it is not known that any great bulk of it is produced, or any whatever preserved. For such storage the production must necessarily take place under conditions precluding the possibility of observation, and beyond the range of our present knowledge to imagine with any approximation to definite conception.

Bitumen, or some similar residue of evaporated petroleum, occurs, as we have seen, in even the oldest rocks, but oil of commercial value first appears in those of the Silurian epoch [see GEOLOGY]. From this early period down to nearly the present era valuable oil-fields occur, at one point or other, in every division of the geological series. Probably the Miocene period was the richest in petroleum-forming conditions, a magnificent birthday endowment for the human race, then in the earliest stages of its biped evolution.

Mode of Occurrence of Petroleum. Two classes of rock combine to furnish the vast and ever-increasing quantity of petroleum annually consumed. These are coarse sands (or sandstones) and crystalline limestones, both of open, porous texture, the one consisting of grains of sand or larger fragments of stone, the other of crystals of carbonate of lime or of the mixture of carbonates of lime and magnesia known as dolomite. In the interstices between the grains or crystals, and in other cavities and fissures, the oil is stored, sometimes under great pressure, shut in by beds of impervious clay or shale, to be discharged as a fountain or "spouter" when the protective covering is pierced by a borehole.

The bending of the originally horizontal beds into arches and troughs by lateral pressure as the cooling globe shrinks in the course of ages and the more compressible rocks are squeezed into such folds, has, in many oil-fields, the beneficial effect of collecting all the water that may have remained from the time of original formation, or have penetrated subsequently, in the troughs, and the gas (which accompanies nearly all petroleum) in the crowns of the arches, leaving the oil on the flanks of the folds, with the cushion of gas to afford the desirable pressure, and the water-seal, as in a trapped drain, to prevent escape downwards.

The arches are termed *anticlinals* (sloping oppositely), and the troughs *synclinals* (sloping together), terms of constant use in the discussion of oil-fields, in that they connote the productiveness or barrenness (in respect of oil) of successive portions of the country thus constituted. As the course of the rivers and minor streams, carving out hill and dale, is largely independent of these bendings of the rocks, effected in ages long past, an anticlinal arch may be, and often is, the floor of a valley, and a synclinal trough the ridge of a hill; the terms refer to the slope of the beds of rock, not to that of the surface, which may be quite level, or fall in a wholly different direction.

In many of the most notable oil-fields salt occurs, either as rock-salt or as strong brine, in close association with the petroleum, pointing to some obscure relation between the accumulation of salt and the original conditions under which oil is formed. It may, however, be due merely to the similarity of surroundings essential for the preservation of either substance in undiminished quantity—namely, the presence of an impervious cover to keep the oil from escaping, and the salt from the access of water. Both rock-salt and brine frequently occur with little or no trace of associated petroleum, but salt, as the more universally distributed substance, generally lingers under the cover which protects oil-deposits.

The Relation of Mud Volcanoes to Petroleum. Mud volcanoes are not infrequent accompaniments of petroleum, and by a supposed connection with true volcanic action have helped to confirm the untenable view of the purely chemical origin of oil. They are, in fact, springs of water, either pure or mineralised, cold or tepid, which, rising through apertures in fine clayey material, carry up mud in such quantity as to produce around the outlet a cone resembling that of a miniature volcano. Such cones are of all sizes, from a fraction of an inch to many yards in height, in proportion to the force of the current which has produced them. They sometimes occur with no trace of petroleum, being merely natural "artesian" wells. When occurring in oil-fields, the speed and carrying power of the current is generally enhanced by gas escaping under pressure, and the ejection of the semi-fluid mud is spasmodic, the pent-up gas, as it nears the surface, forcing a way through the last few inches in bubbles that burst with a sudden "plop," often creating a vibration perceptible for a long distance off. The spontaneous or accidental ignition of the gas of the larger cones increases the superficial resemblance to true volcanic eruptions; but, apart from the disproportion in size, there is no similarity in essential particulars between these cold-watery ejections and the molten outpourings of real volcanoes. Only where the region contains beds of soft, mud-forming material are these cones produced; the phenomenon is unknown in areas composed of more solid rocks.

Continued

THE SHIP READY FOR SEA

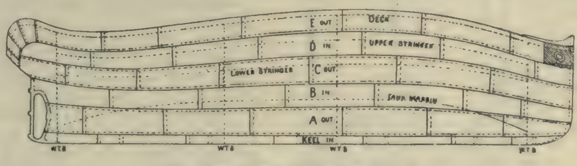
The Preparation and Fitting of Outside Plating. Riveting and Caulking. Launching the Vessel and Fitting Machinery

Continued from page 5743

By Dr. J. BRUHN

THE deck stringers and part of the deck plating are usually fitted before the shell plating, but as the procedure is practically the same in both instances, the details will be described here under the common heading of shell plating. The outside plating is by far the most important from the point of view of strength and weight of structure. It is, at the same time, one of those parts of a ship where first-class workmanship is very essential, in order that a thorough and lasting watertightness may be ensured. The safety of the ship and cargo depends, in fact, in the first instance, on the efficiency of the shell plating. Only experienced fitters, or platers, as they are called, are therefore employed in the preparation of the outside plating.

In the construction of a vessel the most natural and only practical procedure is to begin with the framing of the ship, although it is structurally of secondary importance, being required only to support the primarily necessary shell plating. When the floor plates, with the intercostal girders, and the frames with the stringers, have been erected and faired, and the landing edges sheered, the structure is ready for being plated at bottom, decks and sides. The frames and beams are most naturally and conveniently arranged in a transverse direction, as already described. All the main plating of a ship is, however, most efficiently fitted in a fore-and-aft, or longitudinal, direction. The strakes of plating run, therefore, at right angles, or practically so, to the frames and the beams. The curvature which has to be given to the plates is, of course, that of the frames and beams already in position, but the general arrangement of the plating is shown by a plan handed to the workmen.

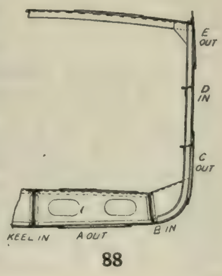


87. SHELL-EXPANSION PLAN

Shell-expansion Drawing. The most direct way of representing to the plater the exact arrangement would be to supply him with a replica of the model which was used in the drawing office in arranging and ordering the plating. It would, however, be inconvenient to carry a model about the yard wherever it might be wanted for reference. It is, therefore, easier to provide the workman with a shell-expansion plan, which is a drawing of the plating, such as shown in **87**. The surface of the vessel cannot be expanded in the ordinary sense of the word, and the drawing shown is produced as follows.

An outline profile of keel, stem, and sternpost is drawn with vertical lines representing the frames. Owing to the reduced scale of the sketch, only the bulkhead frames are shown in **87**. A strip of paper is then bent along a frame line from the keel to the gunwale on the working model described o page 5608. A mark is carefully made on this paper at the intersection of the frame line and the lines of the keel at centre, the edges of the plating, both outside and inside, and the lines of stringers in hold and on beams. This strip of paper is then laid flat on the drawing, along the line representing the corresponding frame, and the marks are transferred to the drawing. When this is done for a number of frames, lines may be drawn through the various points representing the landing edges of the strakes of plating and stringers. In that way a drawing is obtained which shows correct widths of plating and distances between stringers, and correct fore-and-aft distances. It gives, however, a warped view of the form of the individual plates, but this is of no importance, as the plan is intended to show the fitter only the general arrangement of the plates; their exact size and shape he must determine with reference to the marks on and the curvature of the frames. The position of all the butts of the outside plating, as well as those of stringer plates attached to the shell plating, are indicated on the expansion plan, as are also doors, coaling ports, mooring pipes, hawse pipes, water ports in bulwark, and all other openings proposed to be cut in the shell plating. The position of these in relation to the frames, and also their sizes, are given in figured dimensions.

Butt and Edge Attachments. In addition to the shell-expansion plan, the plates may be provided with a midship section of the vessel, as shown by **88**, indicating in section the arrangement of the plating, and containing a written specification of the details of riveting of butts and edges, etc. The usual method of effecting these attachments is by means of riveted overlaps, as shown both for butts and edges in **87**, and for edges in **88**, the overlapped butts being riveted with one, two, three, or four rows of rivets, as shown in **89**, and the edges with one, two, or three rows according to the size of the vessel. The butts which, at the top and bottom of the structure, require the greatest amount of strength are often fitted with a strap on each side, as shown by **90**. It will be seen that the three rows of rivets on each side, arranged in this way, are practically equal to six rows in an overlapped attachment, as they must, in this instance, be torn asunder in two places before the plates can part. The overlapping of the plates at the edges, if arranged as shown in **88**, and on larger scale in **91**, necessitates the fitting of alternate strakes close to the frames, and alternate ones at some distance from the frames, the intervening spaces



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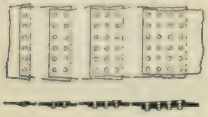
being filled up with what are called *lining pieces*, which are simply strips of iron of a width equal to that of the shell flange of the frames, and fitted between the strakes of plating attached directly to the frames, as shown in **91**. Their thickness must be exactly equal to that of the adjoining plates, and the rivet holes must, of course, correspond with those in the frames. These lining pieces add undesirable weight to the vessel, and necessitate a certain amount of expense in preparation and fitting, and are, therefore, often dispensed with.



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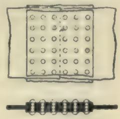

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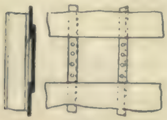
Joggled Plating and Frames. In such cases the outside strakes of plating must be arranged as shown in **92**, by being "joggled"—that is, pressed down in a machine—before being placed in position, so that they may fit tightly to the frames, and at the same time allow the edges to overlap the other strakes. An alternative to this arrangement is the joggling of frames, so as to be brought close to the plating of the outside as well as the inside strakes of plating, as shown, by **93**. The latter arrangement is preferable where the frames are not too deep, and the former where the thickness of the plating is not too great. Where the frames are of great depth, or the plating of great thickness, the cold joggling injures the material to an undesirable extent. The strakes of plating need not necessarily be arranged with alternate ones "in," or bearing directly through the whole of their width on the frames, and with alternate ones "out," or separated from the frames by a parallel liner equal in thickness to that of the adjoining strakes.



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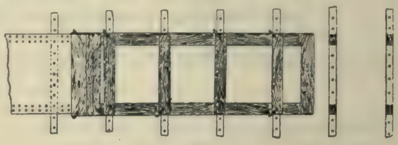
It is sometimes desirable to fit a strake "in and out"—that is, the one edge is inside the adjoining strake, as the lower edge of the strake of plating shown in **94**, and the other one is outside the other adjoining strake, as the upper edge of the strake in **94**. It will be seen that this arrangement necessitates the fitting of a tapered liner, as the full thickness is required at the one edge, and none at all at the other one. This is more costly than the fitting of parallel liners, and "in and out" strakes are therefore not used when they can be avoided. The fitting of the plates of such strakes is also not so convenient a piece of work as the fitting of plates either entirely "in" or entirely "out."

Templating Shell Plates. The outside plates of a ship are prepared by means of the light and convenient templates already repeatedly referred to. These contrivances are placed on the frames in the exact position the plates are to occupy, and the correct dimensions and outline form, as well as all rivet holes to correspond to those already punched in the frames, are marked on the template and transferred, on the ground, from it to the plate itself. The details of the procedure are as follows. The plater prepares, in the first instance, the template from thin parallel wooden battens, which are nailed together to form the outline of the required plate, as shown in **95**. No very great accuracy is necessary in this work as long as the length and breadth of the template are roughly correct. Pieces of batten are then nailed across from edge to edge, so that they may correspond in position to the frames when the rivet holes are being marked. This temporary plate completed, it is taken to the ship and fixed on the frames by means of iron clips as shown in **95**. The inside strakes of plating must clearly be dealt with first, as they must be in position before the outside strakes can be fitted. Figure **95** shows a template in position for a plate of an inside strake. The exact lines of the edges of the plate have, as described on page 5615, been previously indicated on the frames by permanent nicks and by paint marks of the width of the overlaps or landings as seen on the uncovered frames of **95**. It is therefore an easy matter to fix the template on the outside of the frames in such a position that it covers the intended landing edges. The positions of the butts are obtained from the shell expansion plan, and care must be taken to see that all the rivet holes in the frames are covered by the cross-pieces of batten.



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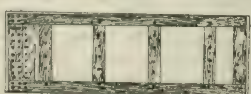
Marking of Templates. The fitting of the plates proceeds from aft forward, as a plate always overlaps on the exterior of the one abaft it. This arrangement is adopted in order that the end of a plate may not meet the water when the vessel is going ahead. The plate abaft the one the template is intended for has therefore been shown in **95** fitted in position with all its holes punched. The template must then overlap it to cover all the rivet holes in the butt; when that is ensured, all the holes are marked with a hollow brass cylinder of the size of the rivets. By dipping it in whiting and inserting it carefully from the inside in the rivet holes white ring-formed marks are made on the wood of the template. When all the holes in the frames and in the butt have been marked in this way, the correct dimensions of the plate must be noted unless the edges of the template happen to correspond exactly with these. In most cases this will not be so, as a fresh template is not made for each plate. One is usually made to serve for a great number, and it is therefore necessary to note on its edges the extent to which it deviates from the exact shape of the plate. The distances from the edge of the template to the intended edge of the plate as marked on each frame are measured and noted on the wood, and the same is done at the butt of the after end so that a correct sketch can be produced of the plate from the incorrect template when the latter is taken down. When the desired plate has been obtained from the stock it is laid on blocks to raise it from the ground, and the template is placed on the top of it as shown by **96**, with the marks of



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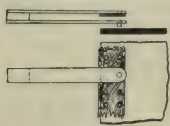
the holes upwards and in such a position that there is sufficient material everywhere to admit of the required size being obtained. The marks on the template must now be transferred to the plate. This is done in various ways as regards the rivet holes, according to which side of the plate it is desired to mark.

Transferring Marks from Template to Plate. In the operation of punching a hole in a plate or angle a slight rim or burr is formed round the hole when the material is forced through the bolster of the machine. It is very important in all riveting that the surfaces of contact should be brought close to each other at all points. The rims produced by the punching would prevent this, and are consequently very objectionable at the surfaces of contact. Both plates and angles are, therefore, whenever it is possible, punched from the contact side, or the *faying surface*, as it is called. The template [**96**] is lying on the inside—that is, the faying surface of the plate, as regards the holes for the frame rivets and the after end butt rivets, which are all the holes marked on the template. The transference of these marks to the plate below is effected by a marker, as shown in **98**. This consists of a long tong-like appliance with two thin wooden arms. In one of these there is a plain round hole of the size of a rivet hole, and in the other one, in identically the same position, there is also a hole, but in this one there is inserted a short wooden cylinder. The template is held in position on the plate by a number of iron clips, but between these it may be lifted slightly by one hand of the workman, while he, by the other, dips the cylinder part of the marker in white paint and inserts the lower arm between the template and the plate, as shown in **98**. He then holds the upper arm in such a position that the hole in it exactly fits one of the marks on the template, and then allows the cylinder part of the arm below to make a ring-shaped white paint mark on the plate. It will be seen that all the holes marked on the template may in this way be correctly transferred to the right surface of the plate. The exact shape of the plate is next drawn in chalk from the shape of the template and the marks on it. Here it is, however, in the case of the edges and the butt of the fore end, necessary to transfer the marks to the other side of the plate, as it will in these instances be the faying surface, and as the shearing of the plate produces a burr similar to that caused by the punching. When the edges, which are usually straight, or practically so, have been struck in with chalk lines on the outside of the plate, the holes for the landing rivets may be marked. This is also to be done on the outside surface of the plate, which is, as stated above, the faying one in this instance. As there are as yet no other holes with which these must be made to agree, they may be marked by striking chalk lines at the proper distance from the edges of the plates and making a cross mark on these lines for the centre of the holes. The number of rivets between two consecutive frames and the width of the overlap or landing are stated on the shell expansion plan. The holes for the rivets in the butt at the fore end of the plates are also marked by means of chalk lines on this, the outside of the plate, from information supplied on the drawing.

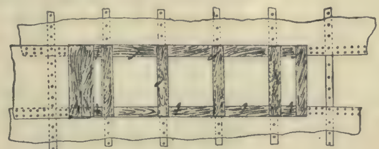
97



98

Punching, Shearing, and Planing of Plates. The plate is now taken to a punching machine, and suspended by a chain in such a way that it is at the level of the bolster of the machine, and can be moved freely in any horizontal direction by the men who assist the plater. The machine can punch only one hole at a time, but with experienced workmen the work can be executed with considerable speed. When the holes marked on the one side have been punched the plate is reversed, and those on the other side are dealt with. The next operation is to pass the plate to a shearing machine, and cut it to the chalk lines showing the required shape. Certain edges of a plate may afterwards have to be planed, in which case a little spare material, about one-eighth of an inch, is allowed for in the shearing operation. The edges of the shell plates are planed to remove the burr and unevennesses caused by the shearing. This is necessary in order that a sufficiently exact fit may be obtained to admit of the joint being made watertight. At all lapped joints there are two edges, but only one—namely, the outside one—is caulked. It is therefore necessary to plane only the outside edges of butts and landings of shell plates. In the case of the plate just considered, which was of an inside strake, only the butt edge at the after end need be planed. When this is done the plate is ready to be bent to its proper form.

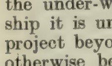
Before explaining this operation it is desirable to describe briefly the marking and punching of a plate of an outside strake. Figure **99** shows a template for such a plate in position on the frames. As the



99

inside strakes are now fitted it is necessary to mark by the brass cylinder and whiting not only the rivet holes in the frames and in the after butt lap, but also those in the landing edges. The only holes that are left to be marked, according to the specification on the shell-expansion plan, are in this instance those for the rivets of the butt at the fore end of the plate, and these holes are also the only ones that have to be punched from the outside surface. A little more care than in the case of an inside strake is exercised in marking on the template the edges of an outside strake of plating, as these edges have to be planed and caulked. In other respects the preparation of a plate of an outside strake is similar to that already described.

Countersinking of Rivet Holes. In the under-water riveting of the shell plates of a ship it is undesirable that the rivet heads should project beyond the surface of the plate, as would otherwise be the most natural arrangement. To avoid this it is necessary to make the rivet hole of a conical shape at the outside, as shown in **100**. The rivet is then hammered up to form a head within the outer surface of the plate. The conical increase in the diameter of the rivet hole is called its *countersink*. The angle of the countersink varies considerably, being much larger in the case of thinner than in thicker plates, as the diameter of the hole at the outside surface of the plate



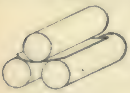
100

is always about 45 per cent. in excess of that at the inside surface, whatever the thickness of the plate may be. When the edges have been planed, the shell plates are brought to a countersinking machine. This is practically an ordinary drilling machine, except that the drill itself is conically shaped, so that it can be readily inserted in the punched holes, and, by the pressure of a lever, made to remove the necessary material to give the hole the required form.

Mangling of Plates. If the plates are for the flat of the side or bottom at the midship portion of the vessel, and if they are not bent or warped, they can be placed in position immediately they are punched, sheared, planed, and countersunk. In most cases the plates are, however, delivered from the steel works in a slightly bulged or bent condition, and it is necessary, even where they are for perfectly flat parts of the vessel's surface, to pass them through the mangling rollers. These consist of two sets of parallel iron rollers, one of which is revolved by the machine. The plate is passed between the two sets, as indicated in **101**, and gets slightly bent in opposite directions as it passes each roll. By repeating this operation in the proper directions all undesirable bends may be removed from the plate, so that it can be taken to the vessel and secured in position with a good fit to the frames and a perfectly plane surface. Even in cases where the form of the vessel is not quite flat, it may be unnecessary to do more than pass the plate through between the rollers, as it may, when free from local deformations, be drawn tight to the frames by means of screw bolts, where the curvature and the thickness of the plate are not great.

101

Where the curvature of the individual plates is great, it is necessary to pass them through a proper plate-bending machine, as shown in **102**. This consists of three long and strong rollers, the two lower ones of which are revolved by the mechanical power supplied to the machine, while the top one runs free and can be elevated or depressed parallel or at either end.



102

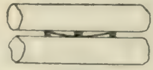
It has already been explained that the plating of a ship is always arranged as far as possible in such a manner that the plates are curved only in one direction. It will easily be understood that it is a very much simpler piece of work to give a plate a cylindrical form than a spherical one. The former can be done without the application of heat, but the latter cannot.

Rolling of Plates with Curvature in One Direction. When a plate is ready to be rolled—say, one for the bilge of the vessel amidships—the fitter goes to the ship and bends a piece of thin iron to the form of the frames in way of the plate. He then passes the plate between the rollers, as shown in **102**, at first with the top roller only slightly depressed. The plate is then rolled backwards and forwards, while the top roller is being gradually moved downwards, thus bending the plate. When the operator judges that the right form may have been arrived at the plate is withdrawn and the curvature checked by means of the bent iron mould. If it is not found sufficient, the process is repeated until the proper form has been obtained.

In the case of the bilge plates amidships the form is cylindrical, and the one mould is sufficient. Nearer the ends the curvature of the plate may not be exactly the same at all frames, and it is necessary to make more moulds; in some instances one may be required at each frame. The lines of curvature may at such places not be parallel to the edge of the plate, but may run more or less diagonally across it. An experienced plater will, however, always be able to judge by a mere inspection of the frames in which direction the curvature is greatest, and the moulds of the frames will be sufficient guide to him in giving the plate its proper form. When the curvature at the one end of a plate is to be greater than that of the other end, the corresponding end of the top roll [**102**] is lowered more than the other one. In this way the plate may be given a conical form, and, strictly speaking, this is the only variation in the form it is possible to effect by the rollers shown. In other words, when the curvature is fixed at the two ends it will be fixed throughout the length of the plate.

Rolling of Plates with Double Curvature. In practice it is, however, possible to vary the curvature within certain limits. If a greater curvature is desired at a certain part of the plate the operator places a thin piece of wood at this point as the plate passes through the rollers. The effect of this is that the plate is depressed relatively more at this place than elsewhere, or the curvature is increased. By gradually increasing the thickness of the wood it is nearly always possible to give the plates the required form without heating them. If the lines of curvature are not parallel to the edges of the plate, it is necessary only to pass the plate diagonally between the rollers, or in the direction in which the operator judges the curvature to be greatest. Here, as in previous cases, it is, of course, necessary to check the curvature at the frame lines by the corresponding moulds during the progress of the rolling. It is usual to speak of the individual shell plates as being in some cases twisted. Mathematically, many plates may be twisted, but it is only to such a small extent that it is in practice not necessary to provide means for the twisting of the plate prior to its being placed in position. What is usually spoken of as the twist of a plate is the shape it assumes when bent diagonally, so that the four corner points are not in the same plane. The extent to which one of the corner points deviates from the plane of the three other points is spoken of as the amount of twist in the plate.

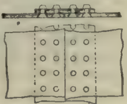
In rolling plates it is particularly necessary to see that the curvature is carried right to the edges of the plate, so that the edge laps fit close together for their entire width. Where the plate is curved both transversely and longitudinally, the curvature in the one direction is, as already explained, small. In such cases the plate is first bent in the transverse direction, and the curvature given to it is somewhat in excess of that actually required, as the subsequent manipulation tends to reduce it. The plate is then passed lengthwise through the rollers, as shown in **103**. To prevent the transverse curvature from disappearing in this process, pieces of wood may be placed, as shown, under the edges and along the middle of the plate while the rolling takes place.



103

Butts of Plates. In cases where the joints of the plates are not effected by means of overlaps considerable care is necessary, in order that the thorough watertightness may be ensured. The plates are here simply butted against each other, as shown

in **104**, the efficiency of the joint depending entirely on the exactness of the fit, as the strap on the inside is not caulked. When the template is being prepared for a butted plate great care must be taken to cut the end of the template in such a manner that it fits hard over its entire width against the plate already in position. The holes for the butt rivets are in these instances marked off at both ends of the plate by chalk lines, according to specification, the butt straps themselves being fitted later by the use of small, separate templates. The ends of butted plates are always planed. When the plate is curved, the butt, in most cases, will not be perfectly straight, and special care is needed to see that the template fits to the plate at every point, when the former is bent to the curvature of the frames. The line of the butt is then drawn on the plate according to the curve of the end of the template, and not to a straight chalk line, and exact permanent marks are made on the plate for the guidance of the planer in producing the curved edge. These marks are made by a centre punch, a necessary tool which all platers carry in their pocket in addition to a piece of chalk. It consists simply of a small piece of hard steel with a strong but fine point. By placing it on a plate and giving it a smart tap by a hammer, a fine, clear, conically-shaped mark, which cannot be defaced, is made on the surface.

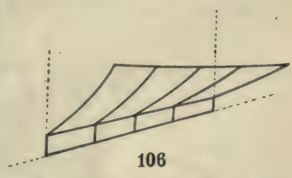


104

Moulds for Garboard Strakes and End Plates. Practically all the plates of the outside shell, inner bottom, decks and beam stringers can be dealt with, as described previously. The inner bottom and the stringers and part of the deck plating are, as already mentioned, usually fitted before the shell plating is in position, and the procedure is the same in both instances; but the work is much easier in the former cases, owing to the flatness of the surfaces and the straightness of the edges of the strakes. In a few instances it may be necessary to apply heat to the shell plates in order that they may be given their proper form. This applies principally to the garboard strakes or the shell plates adjoining a bar keel, and to the very end plates which are attached to the stem or sternpost. Where bar keels are adopted the garboard strakes are flanged, as shown by **105**, to form an attachment. This operation can be carried out on the cold plate in an ordinary flanging machine for the greater part of the midship length of the vessel. Nearer the ends, where the plates themselves are curved, it is necessary to heat them, and the preparing of such plates is, therefore, a somewhat difficult task. In the first instance a kind of rigid template is made of thin iron bars welded together. It is, however, not intended so much for producing the outline of the edges of the plate as for giving the exact form to which it is to be shaped. The template must, therefore, be quite rigid, and a bar is bent to the form of each frame, and the ends welded to a rim representing the outside edges of the plate, as shown by **106**, Other bars may be welded across these to give the mould additional rigidity, and the plate is then taken to the bending slabs, outside the plate-heating furnace. A rough replica is here made of its form in the shape of a bed prepared by iron blocks and logs of wood, more or less protected by iron or steel pieces of plate.

105

Plates Requiring to be Heated. While this bed is being prepared the plate which it is intended for is being heated in the furnace. When it is at a bright red heat it is withdrawn, and as quickly as possible laid on the bed and allowed to settle down to its shape by its own weight, assisted by blows from large wooden mallets that will not leave marks in the softened metal. The aim is to get the shape correct on the whole while the plate is very hot. The smaller adjustments necessary to make it follow the iron bar mould exactly can more conveniently be made while the plate is cooling, when ordinary heavy sledge hammers can be used. The mould is repeatedly applied during the shaping process to enable the operators to check their work. If it should be impossible to complete it before the plate gets cool, it is again heated somewhat in the furnace, but care must, of course, be taken to see that it does not get so hot that it loses the shape it has already acquired. Where very marked local deformations are necessary, it may be desirable to heat the plate at such places in an open fire; but local heating is, as far as possible, to be avoided, as it tends to set up stresses in the plate, besides making it brittle. When the exact form of the plate has been obtained the necessary rivet holes must be marked on it as well as the outlines of its edges. This may be done in the usual way by a template, which is fixed on the frames at the ship.



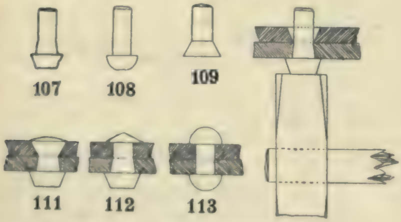
106

Where there is a knuckle or sharp bend, as in the plate shown in **106**, it is necessary to use thin pieces of tin to form a hinge where the two parts of the template are united at the knuckle. The work of marking the holes and transferring them to the plate is otherwise as for all ordinary plates. The plate itself is sometimes taken to the ship and fixed in position, and the rivet holes and edges marked direct without the use of a template. Better work can usually be obtained in this way than by the former method, but the moving and fixing up of the heavy plate is, of course, somewhat more troublesome than the manipulation of the light and handy template.

Fitting of Liners and Straps. While the main items of the ship's structure are being prepared and fitted in place a great number of smaller ones have to be dealt with. In the first instance, as soon as the inside strakes of the shell plating are fitted in position, it is necessary to have the lining pieces, already referred to, prepared. They are only strips of iron of the width of the frame shell flange and of the same thickness as the inside strakes between which they are fitted. If the thickness of these plates differs much it is necessary to taper the liners, or *packing pieces*, as they are also termed, in order that their thickness may agree at both ends with the plates they abut against. The work of fitting these liners is very simple, and is usually left to apprentices or old men. Small templates may be used, which are placed in position, and on which the exact lengths as well as the position of the rivet holes are marked before being transferred to the rolled iron strips.

When the butts of the plating are lapped, as is now usually the case, the end attachment is arranged complete for riveting by the fitting of the adjoining plates themselves; but when the plates are butted against each other it is necessary to prepare and fit butt straps. This is, as a rule, done by another set of men, who can proceed with the work while the plating proper is being fitted. The work is of a similar nature to the preparation of liners, except that it is more important, and greater accuracy is necessary to ensure an efficient, strong and watertight attachment. The straps are considered as small plates, and as such, ordered separately. Templates are again used to determine their exact size and form and the position of the rivet holes. When all the plates and angles of part of the structure have been fitted in position and securely screwed up with bolts inserted in the rivet holes, so that the surfaces of the adjoining parts fit closely to each other, then the process of riveting may be begun.

Shapes of Rivets. The efficiency of the entire structure depends very largely on the quality of the riveting. When anything does go wrong in a ship at sea, as when a leak occurs, or when the structure strains, it is nearly always the rivets or riveting that is at fault. Everything possible ought, therefore, to be done to ensure absolutely sound work in the connecting up of all the individual parts of the structure. The primary necessity for good riveting is fair holes—that is, the holes of each individual item must correspond exactly with those of the adjoining part. The next point is to see that those parts are well screwed up, so that the faying surfaces are fitting quite close together. The shapes of the ordinary rivets used in shipbuilding are illustrated by **107** to **113**. Figure **107** shows a rivet with the so-called

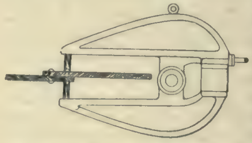


107 108 109 111 112 113

RIVETS USED IN SHIPBUILDING 110

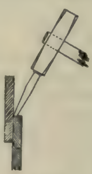
pan head. It is used almost everywhere in the structure where hand riveting is adopted. Figure **108** shows a rivet with a semi-spherical head, called a *snap head*. It is practically used only where the riveting is hydraulic. The rivet shown by **109** has a countersunk head, which is necessary where there must be no projection beyond the surface of the plate.

Riveting. The rivets are heated in a small portable hearth, which can be worked by a boy. The red-hot rivet is inserted in its hole, as shown by **110**, and a heavy holding-up hammer is pressed against its head by a man on the one side of the plates to be riveted together, while one, or usually two men, hammer down the point on the other side. The length of the rivet ought to be such that the projecting amount of material is just enough to form the point-head. In the case of the rivet shown in **110**, it should be enough to fill the countersink and project just a little beyond the surface of the plate. If there is too much material, part of it is rapidly removed by a chisel, and the point-head is formed of the remainder. The hammers used in riveting are moderately heavy ones, with long heads and somewhat flexible handles, and the blows of the two men ought to be delivered quickly and in the proper direction, so that the material of the rivet may be driven into every little space of the hole, and thereby ensure perfect watertightness. Figure **111** shows a rivet hammered up in the outside plating, either in butts, edges, or frames. Figure **112** shows a rivet used where the plates are not countersunk. The point is here simply formed of material hammered down until it assumes a conical shape, projecting a little over the plate. The form of rivet usually adopted where hydraulic power is used is illustrated by **113**, the semi-spherical forms of the head and point being best adapted to the dies of the machine, which simply grips the rivet in powerful jaws as illustrated by **114**, and closes it up in a moment by a steady pressure. Hydraulic riveting is superior to hand riveting, as the great pressure forces the plates themselves together just at the moment the rivet is closed up, but unfortunately it is impossible to use it in many places in a ship.



114. HYDRAULIC RIVETING

Caulking of Plates and Wood Decks. To ensure watertightness of the joints it is in most cases necessary to caulk them after their being riveted. This is a comparatively simple piece of work, consisting in bringing the very edge of the one plate to bear absolutely hard against the joining one at every point. Figure **115** shows a section of the overlap of a landing of outside plating. A tool like a blunt chisel is held as indicated, while it receives smart blows from a hammer. The result is that a small portion of the material at the very edge is slightly displaced and forced against the other plate, thus making the joint watertight. When all edges have thus been caulked, the structure is ready for painting. It is essential to the proper preservation of the steel that it should be efficiently covered by paint or cement. The surfaces ought, therefore, to be dry and well cleaned before they are covered. In the bottom and in all confined spaces cement is, perhaps, the best coating, elsewhere red-lead paint is used as the protective covering. While the structure proper is thus nearing its completion the carpenters may be laying the wood



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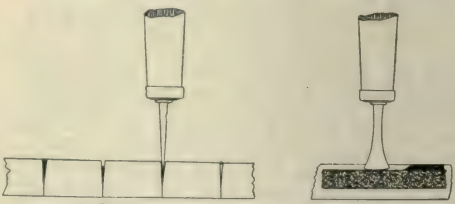


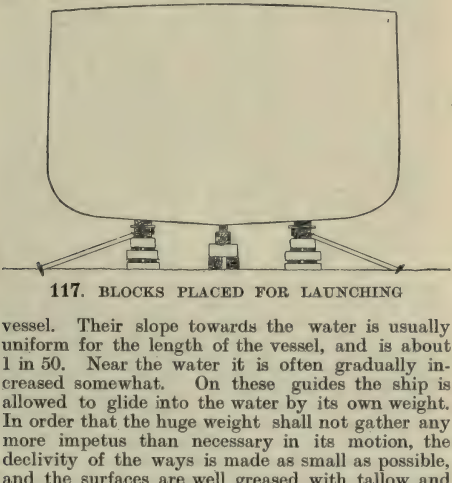
116. CAULKING DECK OF A SHIP

decks, if such are required. They consist of planks, 3 in. to 4 in. in thickness, laid in a fore-and-aft direction, and fastened by means of screws and nuts, either to a steel deck or to the beams, if a steel deck is not fitted. Such wood decks are made watertight, as were the old wooden ships, by means of oakum hammered down [116] so that it

fills the spaces between the planks with a hard composition which will swell when it becomes moist, and thus secure watertightness. After the laying of the decks the joiners take possession of the spaces set apart for cabins or for crews, and fit them up as suitable living spaces, as in the case of buildings on land. The vessel is now completed sufficiently to admit of her being launched or put into the water.

Launching Preparations. It will be easily understood that the moving of a huge structure, weighing possibly many thousands of tons, is an operation not entirely free from risks, and great care must be taken if it is to be carried out without accidents. If the vessel is at all large the carpenters begin the launching preparations at an early moment. In the first instance, the ground is securely piled, if necessary, at the after end, where the weight of the vessel will be passing over it, and where a subsidence at the moment of launching might have a disastrous effect. Two rows of very securely laid blocks are next placed one on each side of the keel blocks, as shown by **117**

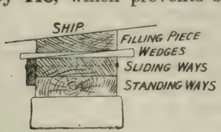
They are parallel to the keel, and extend under practically the entire length of the vessel. On the top of these blocks long lengths of heavy timbers are laid, securely bolted together, and resting everywhere on the cross-blocks. Two wooden sliding rails, called the *standing ways*, are thus formed, the upper surface of which is some 10 to 50 in. in width, according to the size of the



117. BLOCKS PLACED FOR LAUNCHING

vessel. Their slope towards the water is usually uniform for the length of the vessel, and is about 1 in 50. Near the water it is often gradually increased somewhat. On these guides the ship is allowed to glide into the water by its own weight. In order that the huge weight shall not gather any more impetus than necessary in its motion, the declivity of the ways is made as small as possible, and the surfaces are well greased with tallow and black soap to lessen the friction, and thus make a smaller angle of inclination possible.

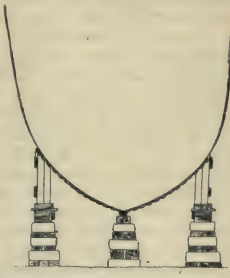
The Launch. When the standing ways have thus been well greased, the sliding ways are laid on the top of them. They consist of timbers bolted together to the same width as the lower ways, but with a guiding piece bolted on the inside, as shown by **118**, which prevents side slipping in the same manner as the projecting part of the tyres on railway wheels. These sliding ways are linked together by short chains where they abut against each other. On the top of them, and with very short intervals, are laid pairs of wooden wedges, as shown by **118**, and over these, again, long timbers fashioned to fit the bottom of the vessel, against which they are forced by the driving in of the wedges. This is done with only moderate force until all the preliminary preparations for the launching are completed. Powerful rams are then used simultaneously at the same points on both sides of the vessel for the purpose of driving in the wedges and pressing the timbers above against the vessel with great force.



118

119. SLIDING WAYS AND VERTICAL TIMBERS

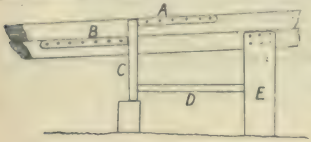
It is not intended thereby actually to lift the structure off its other supports, which could only be done in the case of smaller vessels, but the object is to secure a sound support at the ways when all others have been removed. At the ends of the vessel, where the form is fine, it is necessary to erect vertical timbers standing on the horizontal ones above the sliding ways, as shown by **119** and **120**. The vertical timbers are held against the ship at their head by means of chains passing under the keel of the vessel [**120**]; they are thereby prevented from sliding off the bottom in the wedging-up process. When this has been completed the numerous shores and the bilge blocks that have hitherto, in addition to the keel blocks, supported the structure are carefully removed, until the vessel rests only on the keel blocks and the launching ways. At the last moment the former are also removed. This is done by splitting the uppermost ones of the piles, which are for that purpose comparatively small, as shown by **117**. When the last of these supports has been removed the vessel is standing quite free, and is resting only on the launching ways.



120. VERTICAL TIMBERS AND CHAIN

Methods of Checking Motion of Vessel. To prevent the vessel from moving until the intended moment a keying arrangement is provided near the fore end of the vessel, as shown by **119**. The details of such a holding mechanism are shown by **121**. Two strong pieces of iron, A and B, are securely fastened to the sliding and standing ways respectively in such a manner that a third piece of iron, C, called a *dagger*, can be placed between them. As the sliding ways tend to move downwards, A will press the dagger against B; but the tilting of C is prevented by a dog-shore

D, from a fixed log of wood, E. When all keel blocks have been removed, the dogshores, D, on both sides of the vessel are the only obstacles preventing motion. At a given signal these are knocked down at exactly the same moment on both sides, and the vessel and the sliding ways glide together down into the water with a gradually increasing velocity. If they should not move at once, hydraulic rams are applied to the fore end of the sliding ways until the motion is started. If there is a good width of water to launch into, the vessel is allowed to glide out into the water, and drop its own anchors until tugs can tow her to the berth. If the water, on the other hand, is narrow, it becomes necessary to stop the progress of the vessel before she can be damaged on the opposite bank. This may be done in various ways, the simplest of which is perhaps the one where a number of anchors are fixed in the ground on both sides of the building berth, and placed in pairs. Two strong chains of suitable length are then attached to the bow of the ship and to the lowest pair of anchors, which, again, are connected by chains with the higher situated ones. As soon as the vessel is in the water the first pair of anchors come into operation, and being dragged slightly, the next pair follow, and so on. In this way a vessel can be stopped in a given distance without it being done suddenly.



121. KEYING ARRANGEMENT

Completion of the Ship. The next step towards the completion of the vessel is the supplying her with the engines and boilers, which have been constructed elsewhere while the hull was being built in the shipyard. The work of fitting these is carried out by the engineers, but the shipbuilder must often remove large portions of the structure, particularly at the uppermost decks, in order that there may be space enough to admit the bulky complete boilers and engines. All these portions are, therefore, left unriveted, being merely fitted together with screw bolts for the launching operation. As soon as the machinery is all on board the completion of the vessel can be proceeded with. There remains numerous little things that have to be supplied, fitted, or put in order before the organism of a modern steamer is in working order. Masts have to be supplied and set up with wire rigging. Anchors and chain cables have to be provided with windlass, cranes, and hawsepipes for working them. Derricks and winches have to be fitted for the handling of cargo; mooring bollards must be fixed to the deck to enable hawsers to be made fast when the vessel is in harbour. The steering gear must be put in order. There are usually two steering arrangements—one aft, which works by means of a screw directly on the rudder head; and another at the bridge-house, which is worked by steam power, and connected with the rudder aft by means of chains and iron rods. Ventilators are arranged to bring fresh air down to the passengers and cargo below the deck. Numerous pumps have to be fitted, some with pipes leading to all the many compartments of the vessel. In nearly all steamers there is now a complete installation of electric light. If the vessel is intended for passenger service there is, of course, a complete hotel outfit necessary, but that comes more under the joiners' and upholsterers' business than under that of the naval architect.

Beauty in a Ship. In the creation of a ship's structure questions of appearance ought not to be entirely neglected, nor should the æsthetic requirements be considered satisfied by the illogical fitting of a certain quantity of so-called ornaments which have no organic connection with the structure proper. Ships are first and foremost utilitarian in their object, and if they are constructed with a view to being as efficient as possible in the fulfilment of their duties, they will in virtue thereof possess a considerable amount of structural beauty. The fundamental æsthetic principle in ship construction should, therefore, as in the case of other engineering structures, be the creation of direct evidence of their intended purpose. A ship must float so that a minimum of water from breaking waves is taken on board; she must be stable, strong, and speedy; and all these qualities should be apparent to the viewer. From the fact that she is movable a ship possesses much more of the organic character than do land structures. The fair, curved outlines, beautiful in themselves, should not be recklessly broken, but the details of the structure ought to be made as far as practicable subservient to the preserving of the continuous character of the hull. This is particularly desirable in sailing vessels, where the curve of the sheer of the deck corresponds harmoniously to the outlines of the sails.

Points to Consider in Design. In steamers the conditions are somewhat different, and the fitting of breaks—such as the wells between poops, bridges, and forecastles—may add to the gracefulness of the appearance, as may also the proper arrangement of deck houses, funnels, masts, and other prominent features on the deck. Each of these items may be uninteresting in itself, but their combined effect may be pleasing. The overhanging bow or cut-water is justifiable only when the deck or rail line is continuous, as in sailing vessels, where it implies an organic stretching forward of the structure, which should exclude the possibility of any abrupt discontinuities.

In the arranging of the material of the hull it is always desirable to make the construction directly apparent. Overlapped butts and edges are, therefore, for æsthetic reasons, preferable to flush ones, and when the rivets are above water, good full heads will everywhere look better than the flat, countersunk heads which cannot be seen. The bold projections give a character more becoming to the surface of a large ship than the smooth and sleek paint alone can do. The fitting of iron mouldings is equally objectionable in large steamers, both from the point of view of efficiency and [illegible]. They are in either case too trivial to be of any consequence. All through the construction of a ship the rule holds good that if a really strong and efficient vessel is built it will also be a structurally beautiful vessel.

When a ship is complete the trial trip takes place; but before describing this it is desirable to explain briefly the operation of designing a ship. It was assumed at the beginning of the description of the actual yard operations that the ship was ready on paper or in the thoughts of her prospective builder and owner, so that her construction could be proceeded with at once. It is now proposed to deal briefly with the operations necessary to create this, in one sense, imaginary ship, but, at the same time, one that is absolutely essential to the successful making of the real one.

Continued

THE GROWTH OF SMALL SHOPS

Retailing Enterprise. Expansion in Business. Department Stores. Multiple Shops. Branch Shop Management. Treatment of Employes

Continued from page 5790

THERE are several forms of competition—economic growths of the last few decades—which the present-day retailer has to face. One is the co-operative society, which, from the retailer's point of view, has grown to such alarming dimensions in the North of England, and another is the large city stores. How to combat these forms of competition is a problem the solution of which has been keenly sought but has never been satisfactorily given. We cannot profess to say anything new on the subject, but we can at least express what those who have tried to fight such competition have done.

Fighting Co-operative Stores. We have known flourishing businesses inaugurated cheek by jowl with large co-operative stores. The proprietors of these successful private ventures have been men of strong personality and individuality, who have missed no chance of turning the methods of co-operation against its shops. The business done in most co-operative society shops is, at certain hours of the day, very large, and customers have frequently to wait a very long time before leaving with their wants satisfied. We have known this turned to advantage. A notice, "No waiting here. Immediate attention," has frequently proved an inducement which brought streams of shillings to the till during the hours of congestion next door. This, however, was merely causing some crumbs to fall from the co-operative table, and the crumbs have a way of ceasing to fall when the next great extension of premises takes place in the co-operative store. The inducement of co-operation to the ordinary co-operative members is that it forces them to thrift. They pay high prices for purchases, and receive back the overcharges in money or its equivalent at stated times. Sometimes the system of giving bonuses periodically in the same way has served the private trader well. In such a practice the bonus must be larger than that given by the store, and it should be given just a little before each distribution by the store, also the announcement regarding it should be prominent; otherwise, cheap sales and enterprising advertising are the only methods of inducing custom away from co-operative stores. But the fight is unequal. The private trader has ranged against him weapons such as he cannot command, for the principle of association into co-operation is strong, and has become stronger with the growth of trade unionism. The body of co-operators is nearly entirely drawn from the working classes, and many arguments that might be used with some success if put before middle-class consumers are vain when urged before worshippers at the shrine of "our own shop."

Department Store Competition. To fight the department store is almost as difficult as it is to combat co-operation. The best weapons are a fresh and varied stock, promptness in delivery, and punctuality in attention to details. Some goods should be sold at lower prices than the large stores, and care should be taken to announce the fact.

The largeness of turnover both of the co-operative and of department stores enables them to buy exceedingly well. Sometimes the retail trade can, by association, do as well in buying. And inasmuch as united action is always stronger than individual action, the retailer should always be an active member of the local trade association if there be one.

The Retailer with Ambitions. The unique series of articles which have appeared in this course under the heading Cyclopædia of Shopkeeping has approached the subject from the point of view of the small retailer, and has taken for a basis the minimum capital upon which venture may be made into the respective fields of retailing enterprise with probability of success. Some small shopkeepers are content with their position. So long as his business returns to him a profit sufficient to defray the expenses of a moderately comfortable domestic establishment, and to rear and educate his family fairly well, the average retail shopkeeper eats the bread of thankfulness and, when his appointed time comes, dies in the assurance or hope that the goodwill of his shop will suffice to provide the means of living to those whom he leaves behind. But others of the great body of retailers aspire to something bigger than the small or medium retail shop can offer. It is not a mere hunger for wealth; it is quite as much the legitimate ambition for a wider scope for energy, the desire to organise and control a bigger enterprise than that contained within the walls of a double-fronted double-countered shop. For the man or firm who seeks to spread there are many avenues towards both the upward path of success and the chasm of failure. It is foolhardy to attempt any commercial enterprise without capital adequate to the occasion, and the folly is increased as personal knowledge of the business attempted is deficient. To borrow capital or any large portion of it in the hope of being able to do a larger business, and thus repay it, is a device fraught with great danger. It is always the better plan to develop as capital increases by profits being left in the business instead of being withdrawn for personal or other expenses.

How the Retail Business Grows. The most natural growth, and the most frequent, is that a retail concern engaged in a single branch merely grows larger until it has reached the limit that the district in which it is situated can support. Such a growth is the safest. It depends not at all upon any violent departure from the even tenor of routine. The net profit of the concern may be, say, £600, half of which is taken out by the proprietor, and the other half goes into increased stock, or is used to make better terms in buying, either by purchasing in increased quantities, or by paying more promptly for ordinary purchases, thereby increasing still more the surplus profit in succeeding years. Then the opportunity of renting or purchasing the adjoining premises comes, the stock is spread out to fill both shops, and, with little expense, the proprietor makes double the show he formerly did, and may do double the trade.

But besides the natural growth which we have outlined, and which has its distinct limits, there are four channels by which much greater success may be achieved. There is first the multiple-department shop. The draper takes up house-furnishing as a side line, the ironmonger adds a cycle department,

the chemist makes photographic apparatus a special department, and so on. Thus the Whiteleys and Shoolbreds have been built from modest beginnings. Department has succeeded department, each being placed under separate expert management as it became important enough to warrant such treatment, and our mammoth departmental stores have emerged from the process.

The Multiple Shop. But the departmental store has its limitations. It is a commercial possibility only in the large towns and cities where the consuming public constitute a sufficiently numerous body to support it. This fact has given rise to a new phase of commercial development—to wit, the multiple shop, of which Lipton's is the most prominent example. The multiple shop company offers far keener competition to the small retailer than does the big department store. The consumer has to go to the store. It may be central, but it cannot be at the door of everybody, while the branch of the multiple shop comes and opens at the street corner, not seeking to enlarge itself into a huge concern, but content with the trade which the immediate neighbourhood affords. The small shopkeeper is now between the upper millstones of the departmental and professional stores and the nether millstones of the multiple shop and branch co-operative stores. His ultimate fate is uncertain. Perhaps his last refuge will be found in seeking employment under a multiple shop company or with co-operation. The day of extinction is not yet awhile, but the clock of economic evolution seems to be moving towards it. The small shopkeeper has a harder fight than ever before to preserve "even that which he hath," and his safety as an independent unit in the army of distributors is not to attempt to stem the economic tide which is flowing in to achieve his undoing but to go with that tide and come out on its crest no longer a small shopkeeper but the owner or director of a multiple shop company, or of a large departmental store. Every small retailer cannot realise this dream. Essentially, the battle is to the strong and the race to the swift. The field is favourable for the development of department stores, and especially of multiple shops. The most brilliant commercial geniuses will rise to ownership of these, but more and more will it be necessary for the small retailer to enlist in the service and follow the banner of one or other of these leaders. Our ultimate fate, according to the Fabian Society orators, is that even the agents of distribution will be sucked up by the swelling tide of Socialism, and that everyone in the commercial and producing communities will perforce become servants of the State. The latter prospect need not yet disturb our equanimity. Its realisation is still clouded by a dim mist of unrealised dreams.

We must accept the situation that the multiple shop is a formidable antagonist to most private retail traders and the opportunity of the remaining minority. There remain two classes of enterprise to which retailers, to whom expansion is the breath of life, may direct their attention and energies.

The Retailer Who Becomes a Wholesaler. Retailers grow into wholesalers. The transition is easy and natural under certain circumstances, and is most often witnessed in the provinces. Most of the wholesale houses in provincial centres to-day have had their inception in a small retail business. The district probably contained or was in proximity to a fair number of smaller retail shops whose owners had to purchase in small quantities. The "wholesale" department, originally probably a courtesy title rather than a correct designation, grew until it outsized its retail parent. Its value at first was not so much direct profit from its operations, but that it permitted purchases for the retail department upon a larger scale and at keener prices. When it grew a bit it became an object in itself. Commercial travellers were engaged, and finally the proprietor kicked away the ladder by which he had climbed, casting off the retail branch and raising himself into the supposedly higher social standing of a "wholesale merchant." Such is the history in outline of most of our large provincial wholesale firms of the present day.

Developing into a Manufacturer. Lastly, there passes into the field of our scrutiny the retailer who turns manufacturer. In many departments of commerce the opportunities for such expansion were more favourable than they are to-day, when large establishments and expensive machinery plants are necessary to production upon a sufficiently economical scale to offer combat in these days of excessive competition, when every consumer is looking for the biggest pennyworth his bronze coin can purchase. The most prominent one-time retailers who have risen to be large manufacturers are the immense biscuit-making firms in Reading and elsewhere. A retail baker is of course a manufacturer in a small way, but the difference between the baker who makes bread for household delivery and the companies with acres of factory space who send biscuits to the furthest corners of the seven seas represents a rapidly progressive history of development from the village retail shop to present eminence. The proprietors of Sunlight Soap are also instances of similar enterprise even more rapid in the attainment of success and even more prominent in the industrial world. Many other parallel cases might be cited, but these will suffice.

How Expansion Comes. Of the various methods of expansion which we have reviewed, some are natural and obvious, while others involve departure from established practice. Thus diversion into the field of wholesale trading is natural. It often comes unsought, and thus the retailer has thrust upon him a new department of which he may not at first appreciate the possibilities. Manufacturing is often in the same category. A small furniture repairing department or a small one-man tinsmith's shop may be the germ from which will spring a well-equipped factory with ramifications covering continents. But the remaining two methods which have fallen under our consideration do not usually come in the same natural fashion. The draper who decides to cater for the house furnishing requirements of his customers takes a decided step in a new direction fully aware of what he is doing, and may have laid the foundation of a department store. Similarly, the man who opens a branch shop takes a radical step in a new direction. The first branch shop pays its way in a few months, and he opens a second, taking care to select a locality where there is prospect of immediate profitable returns. Increase in the number of his shops means no more work for him personally. We have heard retailers many times criticise what they called the folly of branch shops, and have frequently heard the objection: "No man can look after all these shops properly; I know that I have my hands full with one." Objectors of this sort are correct. They do find all their time occupied in looking after one shop, and the multiple shop is not for them. The only

man who can make a success of the multiple shop or the department store must be the man of system. He must know how to devolve the conduct of certain of his affairs and of all the details to others. He must be a judge of men, capable of choosing men qualified to fulfil satisfactorily the duties he may place upon their shoulders. Many good business men remain small traders because, thinking that no one can do certain tasks nearly so well as themselves, they want to do everything with their own hands. They fail to appreciate the value of their own time, of their own services in direction. Performance is for subordinates, commanding is for officers, and while an officer should know how to perform, he should know when to refrain from performance. Men who cannot rise above the ranks of the performers will never rise in the army of shopkeepers above the rank of petty officers. Generalships are for those who can take a wide view of the field, and not for those who insist upon limbering the horses with their own hands.

Cash and Credit Trade. There is this attraction about the large department store and the multiple shop system of trading—that, unless in exceptional cases, business is done on a strictly cash basis. There is no capital locked up in ledger debts—goods sold and not paid for at the time. The man who does a large trade upon a credit basis must have a much larger capital than he who adheres to the practice of selling for cash only. He must, indeed, have double the capital engaged. His working expenses are on a higher scale because interest on capital, expenses in bookkeeping, and loss by bad debts are for him items of expenses from which the cash trader is free. Consequently he cannot sell so cheaply as his cash competitor, or if he should elect to sell as cheaply, he cannot make an adequate profit. The weapon of price cutting is a powerful one as an inducement to attract custom, but it cannot be wielded with equal effect by the credit shopkeeper as by the cash retailer. For these reasons the shopkeeper who wishes to make the most of moderate capital should lean towards the multiple shop or department store.

Account Rendering. The shopkeeper who sells upon credit must see to it that his losses by bad debts are near zero. Every shopkeeper has the desire to attain immunity from loss from bad debts, but many neglect elementary precautions that would, if employed, reduce such loss materially. Accounts are rendered to customers periodically, the length of credit being governed by the class of trade, the customers, and the district. Weekly accounts are desirable, and are frequent in trades that supply comestibles. In other trades, monthly and quarterly accounts are the rule, while in a few cases half-yearly and yearly statements are sent out. These last are far too long, and are happily becoming less common than formerly.

Whatever length of credit is given, the accounts should be rendered promptly. It is often a case of "first come first served." Accounts should not be allowed to remain unpaid without notification to the debtor being sent. If the account be a three-months' account, the statement should, if no payment has been made, be rendered again in one month. If this has not the desired result, two weeks later yet another statement should be sent, accompanied by a polite yet firm intimation that payment is desired forthwith. Failing compliance, the debtor should receive in another week a demand a little more peremptory in tone, and, later still, a definite threat that unless payment be made within, say, three days, legal proceedings will be taken to recover the debt. These requests for payment should be made in an ascending scale of severity. An excellent system employs a counterfoil book, having detachable notices, which are affixed to the account one after another, as the application is renewed. The first application after rendering carries an affixed label, which reads: "Fearing that this account may have escaped your notice, I (or, we) beg to call your attention to it." Subsequent applications would read: "Third Application. Kindly let me (or us) have settlement of enclosed account without delay." "Fourth Application. This account is much overdue, and I (or we) must insist upon settlement immediately," and: "Fifth Application. Unless this account is paid within three days, legal measures will be taken to ensure payment." No debtor who has received these successive intimations can complain of harshness, and anything that may befall him later is his own fault. This system is much better than the frequent practice of letting things drift, and when the account is very old, sending in a peremptory notice or a legal summons without previous requests.

The shopkeeper, or a responsible servant, should examine the ledger at frequent intervals—say, weekly—to see what accounts are outstanding, and if action should be taken regarding any of them. No part of the shopkeeping business is more important than this, or demands more careful personal attention. Special precautions are necessary when business is done under the hire-purchase system, and these were considered on page 704.

Debt Collecting. Assuming that repeated applications for payment of a debt have been ignored, there remains for the shopkeeper legal proceedings against the debtor. Some men are so averse from instituting such proceedings that they would rather lose the money owed. This attitude is wrong, and if made a practice, puts a premium on commercial fraud. There are circumstances—such as the misfortune of the debtor—which may cause the creditor to exercise generosity, but when debts have been incurred without a sense of their responsibility, or with the direct intention to evade payment, or when the debtor can pay if he will, the policy should be one of no quarter.

If there are many accounts to collect for which the aid of the law courts has to be evoked, it may be wise to keep a special clerk, familiar with the routine of the court, or it may prove economical to make this work within the province of an ordinary clerk. A little experience will make a clerk familiar with the procedure. But, usually, the number of accounts does not warrant this. There are many societies that do the work, and a peremptory demand from such a society will often bring payment, as it shows that the creditor is in earnest. Membership in such a society costs an annual subscription, which varies in amount according to the privileges granted. It is usually about one guinea per annum, and a commission on the accounts collected is also charged. An alternative method is to hand over all such debts to a solicitor. The procedure regarding action in the County and High Courts, and the course to be followed in the event of judgment, is too complex to describe in detail, and as they are seldom followed, except through the agency of men familiar with them, we shall not describe them here.

Commission to Employes. One of the secrets of most successful businesses where there are many servants in charge of branches or departments is the system of rewarding responsible servants according to results. A manager of a

branch shop receives a salary which varies with the trade—say, 30s. to 40s. a week for a branch oil-shop and 40s. to 60s. a week for a branch drug-shop—and a commission. There are many ways of estimating the commission. It may be reckoned upon turnover, upon net profits, or upon individual sales of certain remunerative articles. The precise method adopted must be decided by the particular conditions of the case under consideration; but the last-mentioned method —that of giving commission upon the sale of certain remunerative articles—is becoming more common, and has fewer objections from every point of view than any of the others.

Restrictive Agreements. The employer frequently binds his managers, assistants, and travellers by the terms of their employment that they shall not, within a specified number of years after leaving their service, open shop within a competing area. There is a good deal to be said both for and against this practice. It is liable to abuse, and its abuse is to be condemned, for the employer is within his right in bargaining that any special information gained and personal connection made by a servant when engaged on his behalf shall not at a future time be turned into a weapon of opposition. The law courts regard with suspicion any restrictive agreement of this nature, and if it be too restrictive in its terms it may not be upheld in the courts. Wise employers wishing to protect their legitimate interests, therefore, will not make such agreements too wide in their application nor too restrictive in their conditions. Thus they will be more likely to have them upheld in the regrettable event of recourse to law being necessary. It remains to be said that the Shop Assistants' Association are combating with all the energy they can put into the fight restrictive agreements whatsoever, and are meeting with a little success in some quarters. In the case of commercial travellers, one has only to look at the advertisements in the trade and daily Press to discover that almost every employer seeks a traveller "with good connection," which means that they wish a man who can transfer to them some of the trade held by one or other of their competitors.

Treatment of Employes. The question of compensation for accident and during illness is an important one for all employers, whether retailers, wholesalers, or manufacturers. The Workmen's Compensation Act (1906) applies to retailers and wholesalers as well as to manufacturers.

An "employer" under the Act means any person who pays any other person to perform some service, and a "workman" is any manual labourer, whatever his earnings; and any other employe earning up to £250 per annum. A shop assistant is a manual labourer, and every shopkeeper's assistant would come under the provisions of the Act. A "casual" worker also comes under the Act if he be engaged in assisting the employer in his business. Thus, an extra porter taken on at a time of extra pressure would be technically a "workman." In sub-contracted work the workman may recover from the principal. The injury for which a servant may claim compensation is any disablement which incapacitates him temporarily or permanently from following his employment or from earning as much as he did before the injury. Any disease arising out of an injury—as blood-poisoning from a cut finger—constitutes a claim for compensation. If the injury does not incapacitate the workman for more than one week, no compensation is due, and if it incapacitates for more than one week, no claim for the first week can be sustained. If the accident arise from wilful misconduct on the part of the workman, no claim can be made on account of temporary disablement, but only in the case of death or serious and permanent disablement. The amount that may be claimed for non-fatal accidents is one-half of the average weekly earnings, but not more than 20s. per week. Thus, an assistant earning 40s. per week could claim 20s. per week during disablement, but an assistant earning 50s. or 60s. per week could not claim more than 20s. When the injury is permanent, the employer must pay half-wages, as stated, for six months, and then, failing an amicable settlement, the servant may claim a sum which, invested in a Government annuity, would yield three-fourths of the weekly wage before disablement. When death results from the injury, "dependants" upon the deceased—including wife, husband, parents, step-parents, children, step-children, brothers, half-brothers, sisters, and half-sisters—may claim compensation up to £150 if the full wages before the injury were less than 20s. per week, and up to £300 if the wages were higher than 20s. If the estate of an employer be not sufficient to meet a claim under the Act, the disabled workman or the "dependants" of a workman fatally injured may take the proceeds of the entire estate and come before the ordinary creditors. Take a supposititious case. Suppose that a small trader and his assistant are both killed by accident—say, an explosion of gas in the shop—and both leave widows and families behind. The wife of the assistant has first claim upon the estate, and the wife of the shopkeeper can claim only what is left after this and the claims of the trade creditors have been satisfied. The law would be exceedingly oppressive in some cases were it not possible to insure against its risks, and it is extremely imprudent not to seek protection by insuring. The premium is usually a percentage upon the amount of the total wages paid, and varies for different trades. The insurer should be careful to see that he is protected against all claims that may be made against him, and his policy should specifically mention that it covers claims under Common Law, the Fatal Accidents Acts, the Employers' Liability Act and the Workman's Compensation Act, 1906. It should also cover "third-party" risks—that is, risks of an accident occurring on his premises to the servant of another employer. Thus, the workman of a painter whom a shopkeeper had employed to do work on his premises might meet with an accident and have a claim against the latter, who would have recourse against the painter; but, in the event of the painter being a man of no substance and being uninsured, the shopkeeper would suffer. The policy should cover risks of such a nature.

Sickness of Employes. Liability for compensation to employes in case of sickness, where the Workmen's Compensation Act does not apply, rest upon common law. Unless there is a clause in the agreement to the contrary, or unless the contrary be proved to be the common practice of the specific trade, a servant is entitled to wages during sickness. Should the employer wish to do so, he may give his servant notice of termination of the engagement, but even then he must pay wages until the notice takes effect.

The notice to which an employe is entitled when the employer desires to terminate the engagement is subject, in the absence of specific stipulation in the agreement of service, to the custom which prevails in the trade. The majority of cases which the law courts are called upon to decide in disputes

between employers and employed relate to this point of notice due, because in many trades there is nothing approaching uniformity of practice in giving notice. The frequency of disputes is a strong plea for a clear definition of the notice to which a servant is entitled in the event of being discharged. A frequent and reasonable practice is that porters and labouring servants should receive one week's notice, assistants two weeks or one month, and travellers one or three months. The rule, whatever it may be, ought to apply both ways—both the employer and the employe having the right to terminate the service by giving the notice agreed upon. The employer is usually considered to have the right to part with any servant at once by giving him wages up to the time when notice would take effect, but an employe cannot leave his employment by forfeiting a similar sum of money. The reason for this is apparent. The employe's claim for wages being satisfied, he can demand nothing more, but the employer has a claim for service, which cannot, unless with his consent, be compensated by a money payment.

Precautions Against Dishonesty. It is not uncommon to insure employes who have the handling of money belonging to the employer in an insurance company doing "fidelity guarantee" business, so that, in the event of the servant misappropriating his employer's money, the latter is repaid the amount by the insurance company taking the risk. The servants so insured are generally cashiers, collectors, and commercial travellers. It is usually the servant who pays the premium, but the rule is not universal in its application. The rate usually demanded varies from 10s. to 40s. per cent. per annum upon the amount of the sum guaranteed. The lowest rate (10s.) applies to servants like ordinary clerks who are not subject to temptations which may come from the constant handling of money, and the highest rate is demanded for commercial travellers working only on a commission basis.

Speculative Buying. The wholesaler and the large retailer may make money by speculative business—that is, buying stock for a rise. A study of the markets and of the conditions which govern the prices of commodities may enable a shrewd man to make far more money than he could do merely by buying for his needs as they arise. But under the stress of modern competition the advantage thus gained is often thrown away—to the public, if the buyer be a retailer, and to the retail trade if the buyer be a wholesaler or manufacturer. To sell at the old price when the market is up, even if the particular article sold may have been well bought before the rise, is folly. The buyer has taken the risk of losing by a fall if his judgment has been in error, and is fully entitled to the extra profit if his foresight has enabled him to anticipate a higher market, and to prepare for it. Want of recognition of this elementary but important business principle causes men to throw away recklessly money that they have honestly earned by judicious buying, and on other occasions their anticipations may not be realised, and they may load up before a market fall, suffering thereby. The wise speculations should be used to discount the unwise ventures, and not thrown away to customers. The desire to do a big trade, and dread lest a competitor should do some business is usually at the bottom of the foolish practice we criticise. Many business men would do far better for themselves if they paid less heed to what their competitors are doing. No man can do all the trade in his district. If some one else chooses to do unremunerative business, let him do so.

Branch Shop Systems. The success of a branch shop depends upon the system devised for its management. The managers of branch shops should be picked men, which means that they must be men with good wages. They should be given an incentive in the form of commission upon business done, and where individual sales can be tabulated, assistants under branch managers should also receive commission in addition to salary. But the knowledge that he has good servants in his branch shops should not restrain an employer from instituting a proper system of checks. Opportunity often leads to dishonesty, and the employer may prevent the opportunity by the introduction of some of the system which prevails in the branch shops of the best governed houses.

In small branch shops a check till should never be absent, and in larger establishments the cashier system may be introduced with advantage. It is the practice in some of the large stores and branch shops that the assistant who makes the sale does not handle the money at all but merely hands the bill to the customer who pays at the cash desk, then returning to the counter for his parcel. Then the cash, the pay slips, and the pay slip counterfoil retained by the counterman should agree in their totals at the end of the day. The system is as nearly perfect as system can be. The only means by which it can be circumvented is collusion between the counterman and the customer, or between the counterman and the cashier, and human ingenuity is unable to devise a system which human ingenuity cannot in some manner outwit.

Periodical inspection, either by the proprietor or his deputy, should be fairly frequent in branch shops, and stock should be taken and a balance struck as often as can be made convenient, or even at some inconvenience.

Most branch shop trading is for cash, but this rule should be elastic to some extent. The manager should be invested with discretionary powers, as many customers insist upon the convenience of accounts, but the terms of credit should be strictly limited in regard to time, and, unless accounts are paid by customers when they ought to be, no more goods should be supplied until they are. The enforcement of this rule may be a little unpleasant, and may cause the loss of a few accounts, but it should be inflexible, as its relaxation may open the door to abuse and loss.

Rules for Employes. The owners of company shops usually form rules to which their employes are expected to adhere. There is a danger of making such rules so sweeping and restricting as to be impossible of obedience, and there is also a danger of making them so inflexible that the responsible manager is deprived of any power of individual action when exceptional cases arise. Success is attained by making servants enterprising and desirous of forwarding the interests of the owners rather than by compelling them to be mere automatons by following arbitrary regulations. The rules, however, should state distinctly the shop hours, regulations regarding holidays and sick leave, terms of engagement (regarding the notice required for its termination, unless this detail is provided for in the individual service agreements), rules regarding the banking of cash, the rendering of sale returns to head office, the record of expenses, stocktaking and stock orders, window dressing (if the business be retail), and the keeping of the necessary books, with the various

responsibilities of the different employes or classes of employes.

The Railway Account. No detail of a business is more frequently neglected than the checking of the accounts of the railway companies for the carriage of merchandise. Every item which appears on the delivery sheet should be carefully checked in several respects. In the first place, the weight of the package or packages should be taken to ensure that the company weighers have not over assessed the consignment. Then the railway classification book [see page 5076] should be consulted to see that carriage is charged under the proper class. Then the railway rate book should be consulted to see that the proper rate is debited. Finally, the total amount, if the consignment is over 3 cwt., should be figured out, and if under 3 cwt., the table of smalls should be referred to. We know some traders whose commercial operations are not extensive, but who save a good deal of money annually by systematic checking of railway companies' charges, and we have heard a railway official say that if everyone were as careful in deducting overcharges as some of those who do, the trading community would pay a good many thousands of pounds less per annum for the transportation of goods. The official expressed the belief that the undercharges just about balance the overcharges, but that the traders who, in his long experience, had pointed out undercharges, could be counted on the fingers of one hand. This is a hard saying.

Local Advertising. It has been stated that the retailer who does not spend as much money upon advertising as he does upon shop rent is a fool. This is sweeping, but it contains a germ of truth. The retailer can make advertising pay—not perhaps by the hackneyed style of announcements with which most local papers are filled, but by really smart advertising that impels attention—brief in its argument, emphatic in its statements, and seasonable in its matter. This sort of advertising cannot well be taught. It is a gift which can, however, be developed. Advantage should be taken of local events. For instance, we remember seeing in a provincial paper a clever announcement at the time of the elections for the local municipal council. A shopkeeper had a prominent space in which he asked for the support of the electors, and offered "as a solution to the many burning questions agitating the community" his large and varied stock of gas-fittings and incandescent mantles. Never be afraid of being unique. But there are many other methods of local advertising which are neglected. The hoardings, the walls of railway stations, the sides of street 'buses and tramcars ought to carry, instead of the announcements of soaps, pills, and cocoas, far more advertisements by local traders, who are much more likely to derive benefit from such space than manufacturers. The trade papers—and there are several appealing to every class of shopkeeping—contain a good deal of matter that suggests advertising ideas, and the man who would be right up to date should subscribe for every trade paper that appeals to his departments. The few shillings per annum that these cost is well invested money, not merely from the advertising point of view, but also for the general trade information purveyed in every issue.

The Mail Order Business. We have not yet considered another important variety of retailing—to wit, the mail order business. A few firms make a speciality of this method of retailing, and some of them seem to flourish by its assistance. The atmosphere in which mail order business flourishes best is that wherein a cash-on-delivery postal system prevails. The cash-on-delivery system is almost explained by its name. It is simply a system of parcel post where the Post Office authorities do not hand over the parcel to the addressee until the latter has paid the value of it as declared by the sender, and after its receipt the amount so received is handed to the sender. Recent attempts by the Postmaster-General to introduce this system into Great Britain met with so strong an opposition from the retail trade that the measure was dropped. Retailers were wise in their own interests in resisting the measure, although, viewed generally, the result might have been good for the community. But there is small likelihood that the C.O.D. system of parcel post will be introduced in our country within the next few years. Still, retail traders cannot hold back the tide of progress indefinitely, and the day is sure to come when the Post Office authorities will act the part of cash collectors for parcels handed by them. When that time comes the cash order method of retailing will rise under the fostering arm of the G.P.O., and will attain a considerable importance within a brief period thereafter. Then will be the opportunity for enterprise, and fortunes will be made in a few years by men able to take advantage of the occasion.

The drawback to the mail order business under present conditions is that the buyer has to send money to unknown people before he gets the goods. The majority of the public are reluctant to do so, although they would be quite ready to order goods and to pay for them at the time of delivery. For these reasons the mail order business has not in this country attained the importance that it has in others.

How to Work a Mail Order Business. Several conditions are essential to success in working a mail order business. It must be done by newspaper advertisement, and the advertisements should be terse, eloquent and convincing. Only an expert advertiser can manage such a business properly. A careful record should be made of the orders received through the various advertisements. Two methods are adopted to this end. When you see an advertisement reading "Apply to Department No. 45," you may be quite sure that the No. 45 is merely a device to enable the advertiser to trace from which advertising medium the order or inquiry has come. Another plan is to vary the address in the advertisement so as to enable the replies to be entered up to the credit of the paper which has induced them. Whatever plan may be adopted a successful mail order advertiser must know what business every individual advertising medium has brought him, and he will wisely drop those that show unremunerative returns and increase the space or the frequency of insertions in those that pay. Other than this, he must have good long profits on the goods he advertises. Job lines appeal to him, as he can often dispose of these at three times cost price. Large profits are essential, as newspaper and magazine advertising is expensive, and this is almost the only channel by which business reaches the mail order man. The business is all cash, and cash before delivery, hence bad debts occasion no loss and bookkeeping is a trifling expense. The mail order seller usually does a large business in a limited number of articles, hence he can buy largely and secure exceptionally good terms.

Continued

PUMPS

Common, Bucket, Force, Suction, Chain, and Screw Pumps. Hydraulic Rams. Pulsometer Pumps

Continued from page 5679

By Professor HENRY ROBINSON

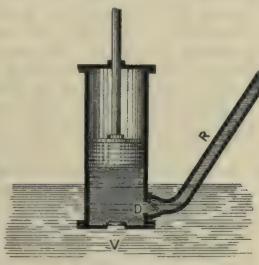
MACHINES for raising water have been known for many ages, and the invention of the common pump is ascribed to Ctesibiers, who was the teacher of the celebrated Hero of Alexandria.

The Common Pump. The action of the common pump may be briefly explained as follows. A piston traversing a cylindrical barrel (having its end immersed in water) is raised, thus producing a vacuum between the under side of the pistonand the surface of the water. The atmospheric pressure on the external water surface causes the water to rise in the barrel to replace the vacuum. This is the principle which causes water to rise in pumps. It will therefore be noted that atmospheric pressure governs the height to which water can be drawn by a vacuum—in other words, the length of the suction pipe of a pump.

The distance of the pump barrel from the surface of the water (that is, the suction) varies with the type of pump employed, but for all practical purposes it does not exceed 25 ft. The delivery, however, may be carried to any height. Where the spout of a common bucket pump is any considerable height from the topmost position of the piston (as with bore-hole pumps) the term "lift-pump" is applied.

The Bucket Pump. The simplest from of suction pump may be described by the "bucket" pump [1], so commonly used by contractors for keeping down the water in shallow workings and trenches. From the illustration it will be seen that the pump consists of a cylindrical barrel traversed by a piston, which is provided with a simple flap valve, V, which opens upwards. The suction end of the pump barrel is reduced in diameter and forms the suction pipe. At the beginning of the upward stroke of the piston the valve closes, a vacuum being formed as previously explained. On the return, or downward, stroke, the water is forced through the valve on to the upper side of the piston, and is lifted by the following upward stroke to the discharge outlet. This completes the cycle of operations. When starting pumps of this description to work, a pail of water is first poured on to the valve, thus closing it, while the first few strokes of the piston are employed in removing the air in the suction pipe to produce the required vacuum. The suction of these pumps is capable of being extended by specially-made lengths which are attached to each other, the joint being made with putty or clay. The maximum length, however, of the suction seldom exceeds 18 ft.

1. BUCKET PUMP



2. FORCE PUMP

Force Pump. In force pumps the barrel containing the suction valve is placed below the water-level [2]. With the upward stroke of the piston the water flows through valve V into the pump barrel, and the valve closes with the downward stroke, which, as the stroke descends, places the water under pressure, causing the discharge valve D to open. The water contained in the barrel is then forced through the valve D into the rising main R. The altitude to which the water can be forced depends on the piston pressure and the friction to be overcome in the rising main. The question of friction in pipes has been dealt with in Water Supply [page 4338].

Suction and Force Pump. This type of pump [3] combines the suction with the force pump. The upward stroke of the plunger P produces a vacuum, which opens the suction valve and draws water into the pump barrel, the delivery valve being closed. The downward stroke closes the suction valve, and the pressure on the enclosed water forces it through the now open delivery valve into the rising main. The action of this pump is what is termed "single-acting"; that shown in **4** is a "double-acting" pump. It will be seen that in **4**, both on the upward and downward stroke, suction and ejection are simultaneously taking place.

The following conditions should be specified when ordering a suction and force pump for hand power:

The barrel to be of gunmetal, with cover, gland, and stuffing box.

The rod to be of hard copper.

The piston to be fitted with best oil-dressed leathers.

Valves to be of best gunmetal, with gunmetal seatings, and doors to give easy access to the valves.

The pump to be fixed within 10 ft. of the surface of the water on a strong staging built into the sides of the well.

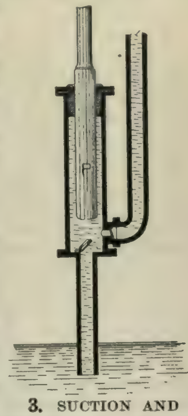
The well rods to be of wrought iron, with roller guides.

The well engine gearing to have two cast-iron side frames, with stretcher bolts, crank shaft, flywheel, two winch handles, and connecting rod.

Suction pipe to be fitted with a rose and foot valve.

Delivery pipe to have an air vessel.

Diameter of suction and delivery pipes is usually less than that of the working barrel. In lift pumps for

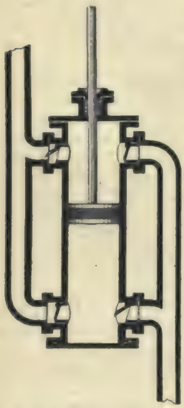


3. SUCTION AND FORCE PUMP. SINGLE ACTING

deep wells the stroke = about 12 in. to 15 in.; diameter of suction pipe, etc. = ⅔ that of working barrel. In force or plunger pumps, diameter of suction pipe = that of plunger. To obtain the working power, add to the weight of the water the frictional resistance of the pipes, also that due to the working parts of the pump and its gearing, usually estimated at one-third of the power applied.

Having briefly explained the chief principles of pumps, we sh ll proceed to deal with some of the various kinds now manufactured; but as this subject covers a very wide field, it wi l not be possible to describe every form of pump. Typical examples will therefore be taken for the purposes of this course.

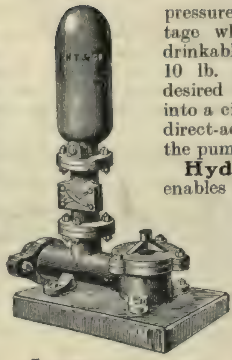
Chain Pumps. These pumps [7] are best for rough work, such as removing sludge or other semi-liquid material, as they are not liable to become choked. With properly designed chain pumps, lifts up to 100 ft. have been obtained.



4. SUCTION AND FORCE PUMP. DOUBLE ACTING

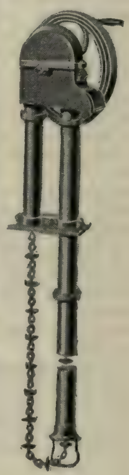
Screw Pumps. Mr. Wilfred Airy many years ago designed an Archimedean screw pump for lifting fluids short heights, which illustrates the great efficiency that is obtainable from a motor which is designed to avoid loss of energy from eddies or shocks in the translation of the fluid. This pump consists of a rotating cylinder having a central core, and one or more spiral passages. It works in a frame at an angle of from 30 deg. to 45 deg. with the horizon, and the velocity of rotation is about 3 ft. per second, measured on the periphery of the cylinder. The lower end is placed in the water to be raised, and the upper end is attached to the delivery. An efficiency as high as 85 per cent. has been obtained by well-designed pumps of this description.

Screw pumps have been used in various places, notably at the Antwerp Water Works, where two Airy screw pumps are now in operation. They are 42 ft. long and 3 ft. in diameter, and are laid at an angle of 30 deg. They are capable of delivering up to 3,500 gallons per minute. Each screw pump is driven by an independent 12-horse-power horizontal engine. Besides being of high efficiency, these pumps have the advantage of being excellent water meters, their delivery being practically the same per revolution at all speeds, and at all depths of immersion on the suction side, so that the half-hourly returns of their number of revolutions enables the accurate measurement of the quantity of water lifted to be obtained. Pumps worked by water pressure may often be used with great advantage when there is, say, a supply of undrinkable water, at a pressure of from about 10 lb. per square in. upwards, and it is desired to pump clean water from a well up into a cistern. The pumps should be of the direct-acting type, the motor cylinder and the pump barrel being all in one line.



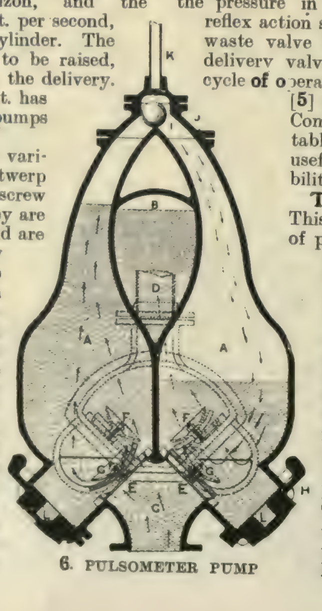
5. HYDRAULIC RAM

Hydraulic Ram. This machine [5] enables the power due to a fall of water to be used directly to raise a smaller quantity of water to a height greater than the fall. The principle of its action is based on the dynamic law that the energy of any body in motion will be absorbed, and consequently the body will be b ought to rest, by any resistance which opposes its motion, if such resistance acts through a sufficient distance. The machine, as ordinarily constructed for small volumes of water, is an iron box containing two valves called the *pulse*, or waste, valve and the delivery valve. An air vessel is mounted over the delivery valve, and the delivery pipe takes off from this air vessel. The mass of water is provided by a pipe of suitable length, which is placed in the tail race. Through the wa te-valve the water freely escapes (for one or two seconds) into the tail race. The contents of the pipe during this time have acquired a certain velocity of flow, producing a pressure on the valve sufficient to raise and close it. This diverts the water on to the delivery valve, which opens, allowing the water to flow into the air vessel against the pressure therein. When the pressure of the water due to the velocity has been absorbed by the resistance of the pressure in the air vessel, a reflex action sets in, causing the waste valve to open and the deliverv valve to close, and the cycle of o erations is repeated. The illustration [5] is one of Messrs. Hayward Tyler & Company's hydraulic rams, and the table cn next page gives some useful information as to their capabilities



7. CHAIN PUMP

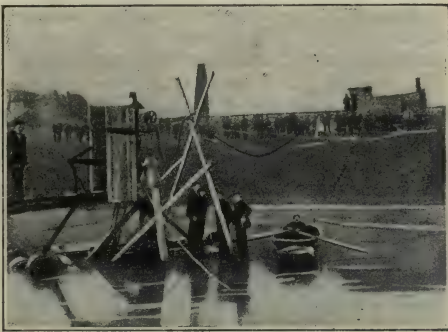
The Pulsometer Pump. This is one of the most useful forms of portable pump [6]. It consists of a casting composed of two chambers, AA, tapering to a common neck, J, in which they terminate in a steam chamber containing a ball valve, I. The ball of this valve oscillates between seats formed in the junction. The illustration shows the ball at rest on one of the seats. The chambers are connected with the suction passage C by valves, EE. A discharge chamber, leading to the delivery pipe D, is provided with valves FF. The air chamber B communicates with the suction. GG are guards to control the opening of the valves EE. The pump being filled with



6. PULSOMETER PUMP

water, either by pouring water through the plug hole in the chamber or by drawing a charge, is ready for work. Steam, being admitted through the steam-pipe K by opening the stop-valve to a small extent, passes down that side of the steam neck which is left open to it by the position of the steam ball, and presses upon the small surface of water in the chamber which is exposed to it, depressing it without any agitation, and consequently with but very slight condensation, and driving it through the discharge opening and valve into the rising main.

The moment that the level of the water is as low as the horizontal orifice which leads to the discharge, the steam blows through with a certain amount of violence, and being brought into intimate contact with the water in the pipes leading to the discharge chamber, an instantaneous condensation takes place, and a vacuum is in consequence formed in the just emptied chamber so rapidly that the steam ball is pulled over into the seat opposite to that which it had occupied during the emptying of the chamber, closing its upper orifice and preventing the further admission of steam, allowing the vacuum to be completed; water rushes in immediately through the suction pipe, lifting the inlet valve E, and rapidly fills the chamber A again. The above action now takes place in the second chamber, completing the cycle of operations.



8. PULSOMETER PUMP ON FLOATING RAFT

CAPABILITIES OF HYDRAULIC RAM

Diameter of drive or injection pipe.	Diameter of delivery or rising main pipe.	Quantity of water available to work the ram per minute.	Approximate number of gallons raised in 24 hours, with a fall of 10 ft. 50 feet high.	100 feet high.	200 feet high.
in.	in.	gal.			
1	½	1 to 4	200 to 800	100 to 400	50 to 200
1½	⅝	4 ,, 10	800 ,, 2,000	400 ,, 1,000	200 ,, 500
2	¾	10 ,, 20	2,000 ,, 4,000	1,000 ,, 2,000	500 ,, 1,000
2½	1	20 ,, 25	4,000 ,, 5,000	2,000 ,, 2,500	1,000 ,, 1,250
3	1¼	25 ,, 30	5,000 ,, 6,000	2,500 ,, 3,000	1,250 ,, 1,500
3½	1½	30 ,, 40	6,000 ,, 8,000	3,000 ,, 4,000	1,500 ,, 2,000
4	2	40 ,, 60	8,000 ,, 12,000	4,000 ,, 6,000	2,000 ,, 3,000

The adaptability of this pump is well shown by **8**, which depicts a pulsometer pump on a floating raft, and supplied with steam from a locomotive.

In reciprocating pumps the momentum necessary to deliver the water to the desired height is produced by a force acting directly on the plunger or piston, the pressure in the pump remaining the same at all speeds, provided the acting force is constant. It therefore follows that the capacity of reciprocating pumps can be varied without change in the total head pumped against; further, if the head is reduced, the quantity delivered by the pump will remain constant at a constant speed.

In centrifugal pumps, on the other hand, the water, after entering the pump, passes through the impeller, where it has a velocity imparted to it due to the form of the vanes and the speed at which the impeller is running.

In many cases small portable hand pumps are necessary to clear workings or trenches from rain-water, or to pump out cellars which have been flooded. This can be done by bucket pumps; but considerable time may be spent in erecting them and changing their position. It is therefore better to employ some more convenient pump, of which there are many on the market.

A useful pump for this purpose is made by Messrs. Duke & Ockenden, and is shown in **9**. As will be seen from the illustration, the pump is fixed to a wheelbarrow and is provided with a flexible hose, so that it can be wheeled from place to place and set to work immediately.

The leverage in an ordinary pump handle is about 6 to 1, and the usual speed at which a man works a pump handle or crank is 30 strokes per minute. To calculate the power required to raise a given number of gallons of water to a given height, multiply the number of gallons per minute by 10 (1 gallon = 10 lb.); this gives the weight of water raised per minute; then multiply by the height in feet, the result is the foot-pounds of work to be done, not allowing for friction. It is very important in laying a long suction-pipe to make sure that it falls along its whole length *from* the pump *towards* the well. If there is any point higher than the pump end of the pipe, it will form an air-lock or trap, from which it may be very difficult to draw away the air. It is always desirable to have a foot valve in the suction pipe to retain the water when the pump is standing.

9. "DANDO" DIAPHRAGM PUMP

In a long suction pipe there is often considerable concussion (especially with single barrel pumps) owing to the stoppage of the advancing column of water at each down-stroke of the pump. To avoid this, and to equalise altogether the working of the pump, it is desirable to place a vacuum vessel (somewhat similar to an air vessel) on the pipe just before it enters the pump.

Continued

continued from page 5722

CARVING FOOD

The Principles of the Art and their Application. Treatment of Poultry, Game, Fish, and the Most Familiar Joints of Meat

By A. B. BARNARD

Among our ancestors carving ranked as a fine art, but a skilled amateur carver is now rare, probably through imitation of the continental fashion of getting the carving done at a side-table and relegating the function to the butler. Yet, that skill in carving is highly desirable, anyone who has ignominiously had to relinquish the carving-knife will readily admit. Bad carving is wasteful, tends to spoil the flavour of the meat, destroys appetite, and wastes time [see HEALTH, page 3314]. On the other hand, it is a pleasure to watch a neat and deft carver as he carefully serves the wing of a fowl or shaves a slice of tongue. A boy or girl should gain experience at the family table, so that he or she may not at some future time get into an awkward predicament when in charge of a joint or bird.

A good carver requires: (1) A sharp carving-knife of moderate length; (2) a two-pronged fork with a guard; (3) a steel which should be used for sharpening the knife *before*, not after, the assembling of the diners. The dish should be conveniently near the carver, of ample size to avoid spattering and spilling gravy, and with a well at one end.

Principles of Carving. The principles to be observed in good carving are: (1) Skill and accuracy rather than brute force; (2) economical cutting; (3) speed, to ensure which plenty of elbow-room is needed, though, as a rule, a good carver manages with less than an indifferent one; (4) deftness and neatness, without apparent exertion; (5) preservation of the appearance of a dish, in view of its return to table next day; (6) knowledge of the anatomy of the animal or bird.

The carver will seek to gratify the tastes of each person, and where these are unknown, will give variety in the helping, with due regard to the amount of lean and fat, and distribution of the "tit-bits."

It is necessary that both dish and plates should be hot when hot food is being served, not merely warm.

For carving poultry, long-handled poultry carvers with stiff blades are needed. Their work is very different from that of meat carvers, and they must be strong, to disjoint the limbs of birds.

POULTRY

Roast Fowl. The fork is firmly inserted in the breast, and the wings are first cut off with a sm ll piece of th breast, and each served with half the liver. The knife is slipped between the thigh and the body, so that the leg can be bent back and disjointed, after which it is easily removed. The merry-thought is detached by plunging the knife in at D, drawing it through C, behind the bone, and forcing the latter forward. The breast is then cut in thin slices, in the direction A to B [1]. Only the carcase of the bird remains, but it supplies two helpings if the back is cut into two pieces across. The breast and wing are usually most liked. A boiled fowl is similarly treated.

Turkey. First cut as many thin slices as possible from the breast, A to B [4]; next serve the wings, and then the legs. The merry-thought is removed in the same way as a fowl's. The stuffing is found in the breast, C to D.

Goose. Make a transverse incision down from the breast-bone to the wing in the direction A to C [6]. Cut fairly thick slices along each side of the breast in the direction A to B. A circular incision, B D E, reveals the stuffing, which is served with a spoon. The wings and legs are then removed, the latter being either cut in two at the joint, or sliced after being turned over.

Duck. If the bird is small it is carved much like a fowl, the wings and legs being first removed, and the breast cut in slices in the direction A to B [3]. The leg is usually preferred to the wing. The stuffing is removed with a spoon after making a semicircular incision C to D. A young duckling may be cut in halves through the breast-bone.

Pigeon. A pigeon is cut in halves along the centre, through the breast and backbone. In the case of a large bird these portions may again be subdivided across. Thus the four helpings consist of two leg portions and two wing portions. Serve with each some of the toast on which the bird is dished.

GAME

Game birds are carved in much the same way as poultry, but, being usually smaller and more delicately formed, they need careful treatment. Let us consider the following birds:

Pheasant. Slices are first cut from the breast, lengthways, in the direction A to B [5], the merry-thought removed, the wings cut off in the direction C to D, and then the legs severed. As in the case of a fowl, the breast provides the best cuts.

Partridge. This may be treated like a pigeon, or like a fowl or pheasant. Another method is to cut the bird into three parts, serving a wing and leg on both sides, and leaving the breast for the third portion. Some carvers hold down the legs, push up the body as one would raise the lid of a box, and cut the breast in halves down the centre. The backbone is regarded as a delicacy. Blackcock and ptarmigan are carved according to size, like pigeons or fowls.

Quails and Plovers. Being small birds, quails and plovers are usually served whole, with toast on which they have been dished.

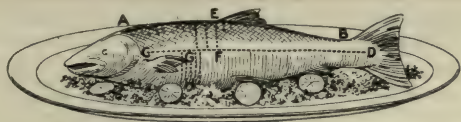
Woodcock and Snipe. The thigh and backbone of woodcock are the "tit-bits." The birds are usually cut in halves down the backbone, and, if sufficiently large, the halves are subdivided. A piece of toast accompanies each portion.

Hare. Slices may first be cut from the part of the back towards the loin, and then the legs may be removed, and the same method followed as in the case of the rabbit. The back pieces are most liked.

Rabbit. A boiled or roast rabbit has the legs first removed, cutting along A to B [10], then the shoulder, cutting along C to D. The back is next cut up into joints, inserting the knife between them and using the fork as a lever. The back cuts are considered the best.

Venison. In carving a roast haunch of venison, the knuckle of which is ornamented with a paper frill, an incision is made down to the bone round the leg, above the joint, so that vent is give to the gravy. Slices are then cut lengthways, in slightly


1. Roast fowl

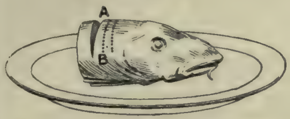

2. Salmon

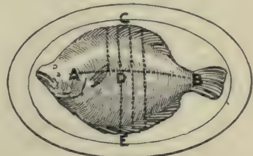

3. Duck

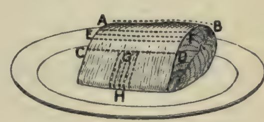

4. Turkey


5. Pheasant

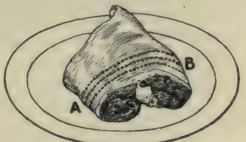

6. Goose

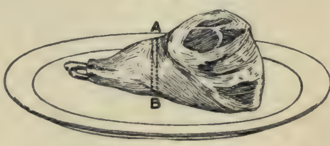

7. Cod's head and shoulders

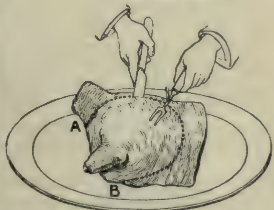

8. Turbot


9. Cut of salmon


10. Boiled rabbit

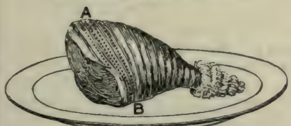

11. Loin of mutton

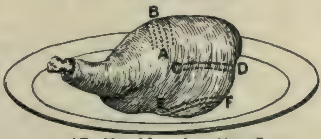

12. Leg of mutton

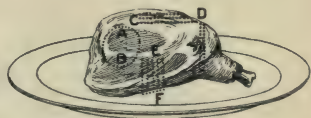

13. Fore-quarter of lamb

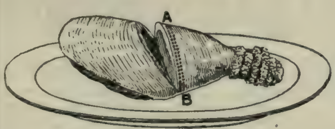

14. Sirloin of beef I.


15. Sirloin of beef II.


16. Roast leg of pork


17. Shoulder of mutton I.

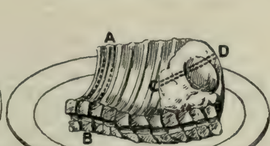

18. Shoulder of mutton II.


19. Boiled ham


20. Saddle of mutton I.


21. Saddle of mutton II.


22. Round of beef


23. Loin of veal


24. Roast ribs of beef

METHODS OF CARVING

curved lines. This joint should be carved quickly, as venison fat, like that of mutton, soon chills.

FISH

It will be noticed that fish belong to one of two forms—flat or round. A plaice or turbot [8] may be taken as examples of the former, and a cod of the latter. Both turbot and cod are divided into two clear halves by the backbone and its projecting bones; but in the turbot the backbone is in the middle, with an equal amount of flesh above and below it, while in the cod the backbone lies nearer the back, with an equal amount of flesh on both sides.

A silver fish-slice is wanted for serving fish; it should have a fairly sharp edge.

Cod's Head and Shoulders. Cut thick slices of the shoulder through the backbone crossways, about 1 in. thick in the direction A to B [7]; these may then be subdivided. Some of the sound and gelatinous part accompanies each plate.

Hake. If the whole fish is boiled, it is served like cod. If fried, it is cut in slices 1 in. thick before being cooked.

Boiled Turbot. Turbot, plaice, brill, halibut, and John Dory are flat fish, therefore the middle is the best part. First cut along the backbone from head to tail in the direction A to B [8]; then cut transverse slices, C to D, and D to E on each side of the backbone. Remove the backbone by slipping the fish-slice under it, and cut the underside in the same way. Serve portions of the gelatinous skin and of the thick part of the fins with each slice of the turbot.

Sole. If the fish is a fair size it is served like turbot; but when small, it is cut up into transverse portions right through the backbone. The head should be cut off and not served.

Mackerel. When the fish is large and boiled, it may be cut into transverse portions, the backbone, head, and tail being lifted intact. When small and broiled, it should be divided in two through the backbone, as also should the curled whiting. The tail-end and roe of mackerel are usually preferred. Haddock and gurnet are similarly treated.

Salmon. If the whole fish is served, make a cut along the middle line of the back in the direction A to B [2]; next make another along the length of the side, C to D, and then cut at right angles between these lines, E to F and G to H. Carve neat slices, serving fat from the under part.

If a cut of salmon [9] is served, the slices are not cut out transversely, but parallel with the backbone [line A to B], also along the natural marking, C to D and E to F. The flakes should remain unbroken, and be accompanied by thin transverse slices from the thin edge part, cut from G to H.

Eels. The natural and easy way to treat eels is to cut them up in sections before cooking.

MEAT

With few exceptions, meat should be cut across the fibre. It is thus far more easily masticated and tastes better. The carver should remember that a joint may have to reappear on the table cold, and it should therefore be kept neat, and not spoilt by careless treatment. A hacked, ragged remnant of a joint is not merely unsightly but unappetising.

Roast Sirloin of Beef. There are two methods of attacking a sirloin of beef; one is to carve the long top slices first parallel with the long bone in the direction B to A [14], the other to carve the undercut or fillet first in transverse slices about ½ in. thick in the direction A to B [15]. The undercut is the most juicy and tender part, and many people prefer to carve it hot, and reserve the upper part to be eaten cold with horseradish sauce. Carving the upper side is facilitated by first severing the meat from the end bone.

Round of Beef. The outside irregular slice is cut off the round of beef, and also off the boiled silverside of beef, in order to get an even surface; then thin slices are cut horizontally in the direction C to B [22]. A thin, sharp knife and a fork with a strong guard are required.

Roast Ribs of Beef. The ribs are carved in the same way as the upper part of the sirloin, in the direction B to A [24].

Roast Shoulder of Mutton. Shoulder of mutton should be neatly carved, the side with most meat being cut first in a transverse direction, B to A [17], then slices cut lengthways along the shoulder-blade, C to D, and a few from the underside, E to F. When the shoulder is turned over the remaining meaty portions are apparent with a gap about E to F, where the slices were cut on the other side [18]. Round slices are cut from A to B, then slices from C to D; a few knuckle slices will then alone remain.

Roast Leg of Mutton [12]. This joint has the first incision across the centre of the leg down to the bone in the direction A to B and slices cut about ⅛ in. towards or away from the knuckle, according to taste, though the knuckle end is better eaten hot than cold. The upper end has some crisp fat, which is regarded as a "tit-bit."

Leg of lamb is cut in the same way.

Saddle of Mutton. Saddle of mutton, which is really a double loin, is best cut the length of the joint, a long cut beng made from A to B down to the bone [20]; then long slices are carved parallel with this from E to F. These slices are then subdivided before serving. Fat will be found in the direction G to H. The joint may also be carved obliquely, as in **21**, after making the incision A to B, as in **20**, and parallel cuts C to D. Slices are then cut obliquely, as shown.

Loin of Mutton. This joint presents no trouble to the carver, provided it has been properly jointed, for it is cut transversely into chops in the direction A to B [11]; these if very large, will allow of a slice being cut between them.

Loin of Lamb, Pork or Veal [23] is similarly treated. With each helping of veal a piece of the kidney and surrounding fat is served, cut from about C to D. The crackling is removed from the pork, and a portion served if desired.

Roast Leg of Pork. Roast leg of pork [16] is carved like a leg of mutton, fairly thick slices being cut in the direction A to B between the strips of crackling. Sage and onion stuffing accompanies the joint.

Forequarter of Lamb. The shoulder is first separated from the breast by cutting round from points A to B [13]. The shoulder is then raised and placed on another dish, either it or the brisket, as the breast of the lamb is called, being reserved to be eaten cold; the shoulder is then carved like roast shoulder of mutton [17].

Boiled Ham. The middle of the ham has the best slices cut in the direction A to B [19], right down to the bone. It is more economical to begin nearer the knuckle and to cut the slices in a slanting direction, so that a fair amount of fat accompanies each one.

Mutton, lamb, and pork may be cut in thicker slices than beef, veal, ham and tongue, and boiled beef thinner than roast.

CATERING *concluded; followed by* BREWING

DICTIONARY OF MENU TERMS

See pages 123-7 and 1956 for system of phonetic pronunciation.

À LA (ah-lah)—In the style or fashion; as *à la Russe*, in the Russian fashion.
Abatis (aba-tee)—Giblets.
Abricots (ab-ree-koh)—Apricots.
Agneau (ī-nyoh)—Lamb.
Ail (ī)—Garlic.
Aloyau de bœuf (aloy-yo-dĕ-bĕf)—Sirloin of beef.
Amandes (am-ongd)—Almonds.
Ananas (an-ah-nah)—Pineapple.
Anchois (ong-shwa)—Anchovy.
Andouillettes (ong-dwee-yet)—Forcemeat balls.
Anguilles (ong-gwee)—Eels.
Appétisans (ap-pay-tee-zong)—Small savouries served between the courses of dinner or before it.
Artichauts (ahr-tee-shoh)—Artichokes.
Asperges (as-pĕrj)—Asparagus.
Aspic (as-pik)—Savoury transparent jelly used for garnishing or moulding cold poultry, fish, etc.
Assiettes (as-syets)—Small entrées or hors-d'œuvres served on a plate, such as biscuits, fruit, etc.
Avelines (av-leen)—Filberts.

BAIN-MARIE (bang - ma - ree)—An open saucepan or kettle of boiling water in which other utensils are placed to warm or cook the contents.
Barbe de capucin (bahrb-de-capu-sang)—Chicory.
Barbue (bahr-bü)—Brill.
Batterie de cuisine (bat-tree-dĕ-kwee-zeen)—Set of cooking apparatus.
Bavaroise au chocolat (ba-vahr-waz-oh-shŏk-oh-lah)—Chocolate cream.
Bécasse (beh-kas)—Woodcock.
Bécassine (beh-kas-een)—Snipe.
Béchamel (behsh-mel)—French white sauce.
Beignets (beh-nyeh)—Fritters.
Betterave (bet-trahv)—Beetroot.
Beurre (bĕĕr)—Butter.
Beurrée (bĕĕr-eh)—Slice of bread and butter.
Bière (bee-air)—Beer.
Bifteck (bif-tek)—Beefsteak.
Bisque (beesk)—Soup made of shell-fish.
Blanchailles (blong-shaī)—Whitebait.
Blanchir (blong-sheer)—To whiten vegetables, fruit, or poultry, etc., by plunging them into boiling water, and then placing them in cold.
Bœuf (bĕf)—Beef.
Bonbons (bong-bong)—Sweets.
Bouchee (bōō-sheh)—Mouthful.
Bouchées d' homard (bōō - sheh doh-mahr)—Lobster patties.
Bouillabaisse (bwee-ya-behs)—Fish soup or stew.
Bouille (bōō-ye)—Boiled meat.
Bouillie (bōō-ye-ee)—Hasty pudding.
Bouillir (bōō-yeer)—To boil.
Bouillon (bōō-ee-yong)—Broth, stock.
Boulettes (bōō-let)—Forcemeat balls.
Bouteille (bōō-tī)—Bottle; as *bouteille de vin*, bottle of wine.
Braiser (breh-zeh)—To stew meat in a braisière or pan.
Braisière (breh-zyair)—A pan made with a ledged lid to hold live coals.
Brider (bree-deh)—To thread together the limbs of poultry, game, etc.
Broche, à la (ah-lah-brosh)—On the spit.
Brugnons (brü-nyong)—Nectarines.

CABILLAUD (ka-bee-yoh)—Cod.
Cacao (kah-kah-oh)—Cocoa.
Café (kaf-eh)—Coffee; as *café au lait*, coffee with milk; *café noir*, black coffee.
Cailles (kī) — Quails; as *cailles sur canapés*, quails on toast.
Canard (kan-ahr)—Duck.
Caneton (kan-tong)—Duckling.
Cannelle (kan-el)—Cinnamon.
Capilotade (kap-ee-loh-tahd)—Poultry hash.
Câpres (kahpr)—Capers.
Capucine (kap-ü-seen)—Nasturtium.
Caramel (kah-rah-mel)—Burnt sugar used to colour or flavour.
Carte, à la (ah-lah-kahrt)—A menu with each item priced, contrasted with *table d'hôte*.
Carré (kah-reh)—Neck; as *carré de mouton*, neck of mutton.
Carrelet (kahr-leh)—Flounder.
Casserole (kas-rol) — Stewpan; game or meat *à la casserole* is cooked in a stewpan or marmite in which it may appear at table.
Céleri (seh-lĕ-ree)—Celery.
Cèps (sehp)—A kind of mushroom.
Cerises (seh-rees)—Cherries.
Champignons (shang-pee-nyong) — Button mushrooms.
Charcuterie (shahr-kü-tree)—Pork-butcher's meat.
Châteaubriand (shah-toh-bree-yong) —Grilled fillet of beef.
Chaudfroid (shoh-frwah)—A dressed cold dish.
Chicorée (shee-koh-reh)—Endive.
Chou (shōō)—Cabbage.
Chou de marin (shōō-dĕ-ma-rang) —Seakale.
Choufleur (shōō-flĕr)—Cauliflower.
Chou rouge (shōō-rōōj)—Red cabbage.
Choux de Bruxelles (shōō-dĕ-brōō-sel) —Brussels sprouts.
Choux verts (shōō-vehr)—Greens.
Citron (see-trong)—Lemon.
Civet de lièvre (siv-eh-dĕ-lee-ehvr)—Jugged hare.
Cochon de lait (kosh - ong - dĕ - leh)—Sucking pig.
Cognac (koi-nyak)—Brandy.
Compôte (kom-poht)—Stew (fish or fruit); as *compôtes d'oranges*, stewed oranges.
Concombre (kong-kombr)—Cucumber.
Confiture (kong-fee-tür) — Preserve, jam
Conserve (kong-sairv)—Preserve.
Consommé (kong - som - meh)—Clear soup.
Coquilles (kok-ee)—Cooked fish or meat served in shells.
Cornichon (kor-nee-shong)—Gherkin.
Côtelettes (kot-let)—Cutlets, chops.
Coq de bruyère (kok-de-brü-yair)—Grouse, blackcock.
Coulis (kōō-lee)—Rich brown gravy used to flavour, thicken, or colour soup.
Courge (kōōrj)—Vegetable marrow.
Crabe (krab)—Crab.
Crapaudine, à la (ah-lah-kra-poh-deen) —Spatchcocked, spread like a frog.
Crème (krehm) — Cream, custard; as *crème à la vanille glacée*, vanilla ice cream; *crème au café glacée*, coffee ice cream.
Crème caramel (krehm-kah-rah-mel) —Custard flavoured with burnt sugar.
Crêpe (krehp)—Pancake.
Crevettes (krev-et)—Prawns, shrimps.
Cromesquis (kroms-kees)—Dice of chicken, game, etc., wrapped in udder of veal or bacon and fried.
Cresson (kres-ong)—Cress, watercress.
Croquette (krok-et)—Ball of potatoes, fried rice, etc.
Croûte-au-pot (krōō-toh-poh)—Clear vegetable soup with croûtons.
Croûtons (krōō-tong)—Sippets of fried bread.

DÉJEUNER (deh-jün-eh)—Breakfast; as *déjeuner à la fourchette*, meat breakfast or luncheon.
Dessert (des-sehr)—Dessert.
Diable, à la (ah-lah-dee-abl)—Devilled; as *dinde grillé à la diable*, devilled turkey.
Dindon (dang-dong)—Turkey.
Dindonneau (dang-don-noh)—Turkey poult.

EAU (oh)—Water.
Échalote (eh-shah-lot)—Shallot.
Écrevisse (eh-kree-vees)—Crayfish.
Églefin (eh-gl-fang)—Haddocks.
Émincé (eh-mang-seh)—Mince.
Entrées (ong-trey)—Made dishes.
Entremets (ontr-meh)—Side dishes served with the second course.
Entremets sucrés (ong-trmeh-sü-kreh)—Sweets.
Épaule (eh - pohl) — Shoulder; as *épaule de mouton*, shoulder of mutton.
Éperlans (eh-pĕr-lang)—Smelts.
Épice (eh-pees)—Spice.
Épinard (eh-pee-nahr) — Spinach; as *épinards à la Colbert*, spinach and poached eggs.
Escalopes (es-kah-lop) — Collops, small beaten pieces of meat or fish.
Escargots (es-kahr-goh)—Snails.

FAISAN (feh-zong)—Pheasant.
Farce (fahrs)—Stuffing or forcemeat.
Fausse tortue (fohs-tor-tü)—Mock turtle soup.
Feuilletage (fĕ-ye-tahj)—Puff paste.
Fèves (fehv) — Beans; as *fèves de marais*, broad beans.
Figues (feeg)—Figs.
Flageolets (flaj-oh-leh)—Young haricot beans.
Flan (flang)—A sort of custard cheesecake.
Foie (fwah) — Liver; as *foie de veau au lard*, calf's liver and bacon.
Fondu (fong-dü)—Melted; as *beurre fondu*, melted butter.
Four (fōōr)—Oven.
Fourniture, de la (dĕ-lah-fōōr-nee-tür) —Sweet herbs for a salad.
Fraises (frehz)—Strawberries.
Frangipane (frang-jee-pahn)—Cheesecake.
Fromage (froh-mahj)—Cheese.
Fromboises (from - bwahz)—Raspberries.
Fricassée (frik-ah-see)—White stew of chicken, fish or game.
Frit (free)—Fried.
Friture (free-tür)—Small fried fish.
Fruit (frwee)—Fruit.

GALANTINE (ga-lang-teen) — Cold meat, fish or game garnished with aspic jelly.
Galette (gal-et)—Buttered roll, cake.
Gâteau (ga-toh)—Cake; also a pudding and a kind of tart.
Gelée (jel-eh)—Jelly; as *gelée à la crème fouettée*, jelly with whipped cream; *gelée à la Russe au citron*, lemon sponge.
Gibier (jib-yeh)—Game.
Gigot (jee-goh)—Leg of mutton.
Gingembre (jang-jom-br)—Ginger.
Glace (glahs)—Ice.
Glacer (glah-seh)—To glaze; to ice.
Glaze (glahz)—Stock boiled to a jelly, used for garnishing.
Gras double aux oignons (grah-dōōbl - oh - zoi - nyong) — Tripe and onions.
Gratin, au (oh-gra-tang)—With grated cheese.
Grenouilles (gren-wee)—Frogs.
Griller (gree-yeh)—To broil; to grill.
Groseilles (groh-zī)—Currants.
Groseilles à maquereau (grōh-zī-zah-mak-roh)—Gooseberries.

HACHIS (hash-ee)—Hash.
Harengs (hah-rang)—Herrings.
Haricots blancs (hah-ree-koh-blong) —White beans.
Haricots d'Espagne (hah-ree-koh-des-pīn)—Scarlet runners.
Haricots verts (hah-ree-koh-vehr)—French beans.
Herbe sèche (erb-sehsh)—Dry herb; *de petites herbes*, sweet herbs for a salad.

Homard (hom-ahr)—Lobster.
Hors-d'œuvres (or-dĕvr)—Small dishes served before the soup.
Huile (weel)—Oil.
Huitres (weetr)—Oysters.

JAMBON (jam-bong)—Ham.
Julienne (jü-lyen)—Vegetable soup.
Jus de viande (jü-dĕ-vee-ongd)—Gravy.

KARI (ka-ree)—Curry.

LAIT (leh)—Milk.
Laitance (leh-tongs)—Roe.
Laitue (leh-tü)—Lettuce.
Laitue pommé (leh-tü-pom-meh) Cabbage lettuce.
Langouste (lang-gōōst)—Crawfish.
Langue (long [*hard* g])—Tongue.
Lapereau (lap-roh)—Young rabbit.
Lapin (lap-ang)—Rabbit.
Lard (lahr)—Bacon.
Legumes (leh-güm)—Vegetables.
Lièvre (lee-ehvr)—Hare, as *lièvre à la Daube*, jugged hare.
Longe (longj)—Loin; as *longe de veau*, loin of veal.

MACÉDOINE (mah-seh-dwahn)—Vegetables or fruit mixed for a garnish or compôte; as *macédoine de fruits rafraîchis*, mixed iced fruits.
Mâche (mahsh)—Corn salad.
Maigre (mehgr)—Broth, gravy or soup made without meat.
Maître d'hôtel, à la (ah-lah-mehtr-doh-tel)—Served with parsley butter.
Maquereau (ma-kroh)—Mackerel.
Marinade (ma-ree-nahd)—Pickle.
Mariné (ma-ree-neh) — Pickled; as *oignons marinés*, pickled onions.
Marrons (mahr-rong)—Chestnuts.
Matelote (mat-lot)—Fish stew made with wine or cider.
Mayonnaise (meh-yon-ehz) — Salad dressing or cold sauce of eggs, oil, etc.
Mélasse ((meh-lahs)—Treacle.
Menu (mĕ-nü)—Bill of fare.
Meringue (mĕ-rang)—Icing of beaten whites of eggs and sugar.
Merlan (mer-lang) — Whiting; as *merlan au gratin*, baked whiting.
Merluche (mer-lüsh)—Smoked haddock.
Mirotons (meer-oh-tong) — Slices of meat larger than collops.
Morue (mo-rü)—Salt cod.
Moules (mōōl)—Mussels.
Mouton (mōō-tong)—Mutton.
Mousse (mōōs)—Frothy ice-cream.
Mûres (mür)—Mulberries.

NATUREL, Au (oh-na-tü-rel)—Plainly cooked, such as boiled in water.
Navets (nav-eh)—Turnips.
Noir (nwahr)—Black, burned; as *beurre noir*, browned butter.
Noisettes (nwah-zet)—Nuts.
Noix (nwah)—Nuts, walnuts.
Nougat (nōō-gah)—Sweetmeat made of almonds.

ŒUFS À LA COQUE (ĕf-zah-lah-kŏk) —Soft boiled eggs.
Œufs brouillés (ĕf-brwee-yeh)—Mumbled (scrambled) eggs.
Œufs frits au jambon (ĕf-free-zoh-jang-bong)—Fried ham and eggs.
Œufs pochés (ĕf-posh-eh)—Poached eggs.
Œufs sur le plat (ĕf-sür-lĕ-plah)—Fried eggs.
Oie (wa)—Goose.
Oignons (oi-nyong)—Onions.
Omelette (om-let) — Omelet; as *omelette aux confitures*, jam omelet; *omelette aux fines herbes*, omelet with finely-chopped herbs; *omelette sucrée*, sweet omelet.
Orge (orj)—Barley
Oseille (oh-zī)—Sorrel.

PAIN (pang) — Bread; as *petit pain*, or *pain mollet*, roll.
Pain bis (pang-beess)—Brown bread.
Pain de froment (pang de-froh-mong) —White (wheaten) bread.
Pain d'épices (pang-deh-pees) — Gingerbread.
Pain de seigle (pang-dĕ-sehgl) — Brown bread.
Pain rassis (pang-rah-see) — Stale bread.
Pain tendre (pang-tongdr) — New bread.
Panais (pan-eh)—Parsnips.
Paner (pan-eh)—To cover meat, etc., with fine breadcrumbs before cooking.
Papillotes (papee-yot)—Paper cases; as *rougets en papillotes*, red mullet in paper cases.
Parmentier (pahr-mong-tyeh) — Potato soup (thick).
Pâté (pat-eh)—Pie; as *pâté de volaille* chicken pie.
Pâté de foie gras (pat-eh-dĕ-fwa-grah)—Goose liver paste.
Patisserie (pa-tis-ree)—Pastry.
Pêches (pehsh)—Peaches.
Pêches à la Cardinal (pehsh-zah-lah-kahr-dee-nal)—Split peaches with raspberry syrup.
Perdrix (pair-dree)—Partridge.
Persil (pair-see)—Parsley.
Petits fours (ptee-fōōr)—Small fancy cakes.
Pièce de résistance (pee-ehs-dĕ-reh-zees-tangs)—Principal dish of the dinner.
Pièce montée (pee-ehs-mong-teh)—Decorated dish.
Pieds (pee-eh)—Feet; as *pieds de veaux*, calves' feet.
Pigeons (pee-jong) — Pigeons; as *pigeons en compôte*, stewed pigeons.
Piqué (pee-keh)—Larded with strips of fat bacon.
Pluvier (plü-vyeh)—Plover.
Poireau (pwah-roh)—Leek.
Poires (pwahr)—Pears; as *compôte de poires*, stewed pears.
Pois (pwah) — Peas; as *pois carrés*, marrow-fat peas; *pois cassés*, split peas; *petits pois*, green peas.
Poisson (pwah-song)—Fish.
Poitrine (pwah-treen)—Breast.
Pommes (pom)—Apples.
Pommes de terre (pom-dĕ-tair)—Potatoes.
Porc (por)—Pork.
Pot au feu (pot-oh-fĕ)—Broth and boiled meat.
Potage (pot-ahj) — Soup; as *potage fausse tortue*, mock turtle soup.
Pouding (pōō-dang) — Pudding; as *pouding de groseilles noirs*, black-currant pudding; *pouding au citron*, lemon pudding; *pouding de Noël*, Christmas pudding; *pouding de pommes*, apple pudding.
Poulet (pōō-leh)—Fowl.
Poussins en casserole (pōō-sang-zong-kas-rohl)—Young chicken stewed in a pan.
Prix-fixe, à (ah-pree-fix)—A meal at fixed charges.
Pruneaux (prü-noh)—Prunes.
Prunes (prün)—Plums.
Prunes de damas (prün-de-dam-ah)—Damsons.
Purée (pü-reh)—Thick soup made from vegetables or meat boiled to a pulp.

QUEUE DE BŒUF (kĕ-ee-dĕ-bĕf)—Ox-tail soup.
Quenelles (kwen-el)—French force-meat balls.

RADIS (ra-dee)—Radish.
Ragoût (ra-gōō)—Hash or stew.
Raie (reh) —Skate.
Raifort (reh-for)—Horseradish.
Raisins (reh-zang)—Grapes.
Raisins de Corinthe (reh-zang dĕ kor-int)—Currants.
Raisins secs (reh-zang-sek)—Raisins.
Réchauffé (reh-shoh-feh) — A dish warmed up.
Reine (rehn)—Chicken broth.
Reine-claude (rehn-clohd) — Greengage.
Remoulade (rĕ-mōō-lahd) — Salad dressing.
Rhubarbe (rü-bahrb)—Rhubarb.
Ris de veau (ree-dĕ-voh)—Sweetbread.
Rissoles (ris-sol)—Puff paste filled with fish, meat, etc., and fried.
Riz (ree)—Rice.
Rognons (roi-nyong)—Kidneys.
Rôti (roh-tee) — Roast; as *oie rôtie*, roast goose.
Rôtie (roh-tee) — Toast; as *rôtie au beurre*, buttered toast.
Rôts (roh)—Roasts.
Rouelle (rōō-el)—Fillet; as *rouelle de veau*, fillet of veal.
Rougets en papillotes (rōō-jeh-zong-pa-pee-yot)—Red mullet baked in cases of oiled paper.

SALÉ (sa-leh)—Salt; as *beurre salé*, salt butter.
Salmis (sal-mee)—Ragout or stew of game.
Salsifis (sal-see-fee)—Salsify.
Sauce (sohs)—Sauce; as *sauce piquante*, sharp (pungent or acid) sauce; *sauce au beurre*, melted butter.
Saucisse (soh-seess)—Sausage.
Saucisson (soh-see-song) — German sausage
Sauge (sohj)—Sage.
Saumon (soh-mong)—Salmon.
Sauté (soh-teh)—Fried in a saucepan kept moving.
Sauvage (soh-vahj)—Wild.
Sel (sel)—Salt.
Selle (sel)—Saddle; as *selle d' agneau*, saddle of lamb.
Soles (sol)—Soles.
Soufflé (sōō-fleh)—Sweet, light pudding made with whipped white of egg; also savouries of fish, fowl or game.
Sucre (sükr)—Sugar.

TABLE D'HÔTE (tahbl-doht) — A meal at inclusive charges.
Tarte (tahrt)—Tart; as *tarte aux (de) pommes*, apple tart.
Tartine (tahr-teen)—Slice of bread.
Tartine de beurre (tahr-teen-dĕ-bĕr) —Slice of bread and butter.
Terrine de crevettes (tĕ-reen-dĕ-krĕ-vet)—Potted shrimps.
Tête (teht)—Head.
Thé (teh)—Tea.
Thym (tang)—Thyme.
Timbale (tam-bahl)—Border of pastry, macaroni, or crust filled with meat or game.
Tomates (toh-maht)—Tomatoes.
Topinambours (top-ee-nam-bōōr)—Jerusalem artichokes.
Tortue (tor-tü)—Turtle soup.
Tournedos de bœuf (tōōrn-doh-dĕ-bĕf)—Small fillets of beef served on fried croûtons.
Tourte (tōōrt) — Fruit pie; as *tourte aux (de) pommes*, apple pie.
Tourbot (tōōr-boh)—Turbot.
Tranche (trongsh)—Slice.
Truffes (trüf)—Truffles.
Truite saumonée (trweet soh-moh-neh)—Salmon trout.

VEAU (voh)—Veal.
Venaison (ven-eh-zong)—Venison.
Viande (vee-ongd)—Meat.
Vin (vang)—Wine.
Vol au vent (vol-oh-vong)—Puff paste crust, enclosing meat, fish, fowl or fruit.
Volaille (vol-ī)—Poultry.

MILLINERY FOR CHILDREN

The Making and Trimming of All Styles of Children's Hats and Bonnets. Dutch and Drawn Silk Bonnets. Polo Caps. Children's Picture Hats

MILLINERY continued from page 5775

By ANTOINETTE MEELBOOM

HOW to take measurements and make patterns for children's bonnets has already been treated [page 4768], and we must now proceed to the cutting, making, and trimming.

Three points must be remembered in all children's millinery: simplicity and lightness of style, softness of foundation, and softness of material.

Shape foundations are usually made of domette, leno, book muslin, or stiff net. The materials used are generally swansdown cloth, bengaline, cashmere, corduroy, fine cloths, and Japanese silk.

The head-lining should be of sarcenet or mull muslin. The trimmings may be of swansdown, different kinds of white fur, lace, embroidered chiffon, baby ribbon, ruchings, ribbons, quills, tips, appliqués, pompons, etc.

It is best to use washing ribbon for children's bonnets and pelisses. It is made in two widths, 3 in. and 5 in. wide, and is uncrushable and washes well. In appearance it resembles a surah ribbon, and it is made in white and cream.

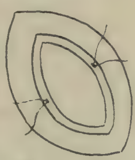
A Baby's Bonnet. A baby's first bonnet can be made in the shape of a hood [180]. Cut two pieces of material the same as pattern, and stitch together round the edge, the right sides inside, cording it between if preferred. Cut away the head part of one to about 3 in. from the edge. Turn it on to the right side, and tack a layer of wadding, domette, or flannel over the single material in the centre. Face this with a piece of sarcenet silk, and run or machine-stitch a sarcenet ribbon on both sides over the cut edges. Mark the centre-front and back, and make an eyelet hole in the ribbon at those places.

Run in China ribbon, secure it at each side, pulling the ribbon front and back to the size of the baby's head. Trim the bonnet with swansdown or lace, and sew on washing ribbon strings, and a cap front, which can be bought ready made or can be very easily made by hand.

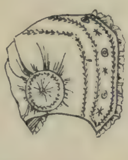
Cap Front. A cap front is made of fine net edged with lace, or lace about 1½ in. wide. Cut two strips of net edged with lace 36 in. long, and pleat it in close boxpleats or quill, making it a little fuller on the top, and catching in the ends. Bind the edge with a strip of firm muslin, 14 in. long when made, the usual length of these cap fronts. This pattern can be enlarged or reduced, and it is made without any wire.

For summer wear, embroidered cambric, muslin, narrow rows of Valenciennes lace sewn together with fancy stitch in silk, or all lace, can be used, left transparent or lined with a thin silk lining of white or coloured silk.

For winter wear [181] the bonnet can be made in velvet, embroidered by hand, or of bengaline silk with fancy stitching, or cloth, and trimmed with fur or lace appliqués. These bonnets can be kept quite plain, with only a silk cord round the edge. Large soft silk rosettes at each ear give a pretty finish becoming to some children's faces. For others the rosette will look better if placed higher. When using washing materials make them up in the same way, but use no stiffening.

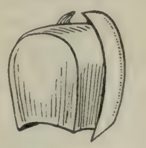


180. BABY'S BONNET

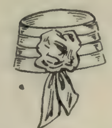


181. VELVET BONNET

182. BOY'S PICTURE HAT



183. DUTCH BONNET



184. POLO CAP

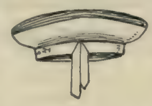
Baby Girl's Bonnet. The materials required for a baby girl's first bonnet are 1 yard of silk, 2½ yards of lace 1 in. wide, 3 yards of insertion, 1½ yards ribbon, and some twist. The bonnet can be made without a shape, with only a narrow band of double muslin ½ in. wide, measuring about 14 in. long (measurement, from ear to ear round front), and 11 in. long from ear to ear round back. This slip will give the required firmness round the edge and help to keep the bonnet in position. Bind the edge with sarcenet ribbon or narrow silk to make it quite neat inside.

For the crown cut a strip of silk 15 in. wide and the width of the silk on the straight. Make three ½-in.-wide tucks, insert a strip ¾ in. wide of Valenciennes insertion lace, and continue till there are three rows of insertion and four sets of tucks. Gather the edge to size of band round face, and draw up the tucks to shape.

Gather the remaining edge, leaving about 2½ in. at each end, join neatly, and arrange the gathers round a piece of muslin cut in a round about the size of a half-crown. Cover this with silk and trim it. Sew the lower edge to the band, which will form the back of the bonnet.

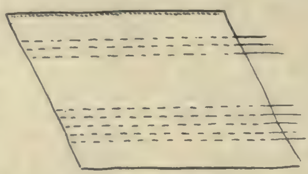
As no head-lining is required, cut another round of silk and slip-stitch it neatly over the

round inside the bonnet, to keep it quite neat inside. Cut a strip of silk on the cross about 6 in. through. Fold this in half and lightly run a ruching of silk or chiffon, or a frill of Valenciennes lace, on the double edge. Mark the centre and slope the ends to 1½ in. Pleat this frill in box-pleats round the front of bonnet, keeping most of the fulness to the top, and finish it off with narrow ruching all round the bonnet. The strings may then be sewn on.



185
MAN-OF-WAR HAT

Baby Boy's Hat. For the foundation of a hat suitable for a baby boy make a band the size of the child's head in double book muslin or net. Cut a circle, 14 in. to 18 in. in diameter, of the material, interlining it, and use sarcenet for head-lining. Gather it round the edge and sew to band. Trim with a ruche of lace or ribbon round band, a rosette, quill, or pompon. Slip-stitch the head-lining round band. Finish with lace cap-front, and strings.



186. SILK FRILLS

These hats can also be made with full crowns, and box-pleated silk or ribbon about 5 in. wide, edged with swansdown, can be used for brim. For trimming, turn up the brim from the face, holding it in place with pompon or rosette.

For older boys white felt hats with dome or square crowns are suitable [182]. Line the brim with gauged silk or chiffon, or only the edge can be trimmed with gauged tucked silk, about 1½ in. wide on either side when finished. Place a ribbon ruche round crown and finish with tips (coming over brim in front, where it is caught to the crown), a rosette of soft silk, strings, and cap-front.

Small polo caps [184] covered in bengaline, and simply trimmed with a large soft silk rosette on one side, are also much worn.

Dutch Bonnet. Little Dutch or Puritan bonnets are suitable for little girls of from two to four years of age [183]. These have generally a coronet, of which there are a great variety of shapes [49, 50, page 4767].

Cut the pattern in buckram, without turnings. Wire round the back part, leaving 1 in. at each side. Wire-stitch the front on to the back, and then wire all round the bonnet, nipping over the 1 in. left at each side and overlapping the wire for 2 in. at the centre-back.

Mull all the edges and wire and mull the coronet, which is covered before it is sewn to the bonnet, in the same way.

Covering the Shape. To cover the shape place the material with the front to the cross, allowing ½ in. turnings all round. Cover the back part of bonnet first, fitting it carefully and sewing the turnings to the front of the bonnet.

Fit the front part, turn in the edge at back, and fit it tightly round the edge of the shape. Catch-stitch the turning on the inside of the buckram in front. Then cut the lining the same shape as pattern, make up and slip-stitch it in the bonnet. Cover the coronet with the material and face it inside with silk. Slip-stitch the edge of the coronet to the edge of bonnet, and make a quilling of lace, chiffon, or ribbon and sew on front.

Trim the coronet with hand embroidery, lace, appliqués, or edge it with fur or kilted ribbon. Another pretty method is to cover the coronet with gathered or gauged silk or chiffon, or with velvet or velveteen, hand embroidered.

Instead of coronets, a very full accordion-pleated silk material, cut on the cross, doubled and lined, and cut narrower at the ears, or gathered or box-pleated, may be made and sewn to the front of bonnet. With a very full front it looks better to have the back fancifully draped or gauged.

Boy's Man-of-War Hat. The only measurement required for a boy's man-of-war hat is the size of the head. Half a yard of double-width material will make two hats. The other materials needed are buckram, 1¼ yards of ribbon, canvas, wadding, ½ yard sarcenet or satin [185].

Cut two circles 10 in. to 12 in. in diameter in material, muslin, and lining.

Make a band 1 in. to 1½ in. wide of buckram or double canvas, or of linen for washing hats, and in length 1 in. longer than head size. Join and wire top and bottom. Mull and cover with material.

Having finished the foundation, place two pieces of material with the right sides facing each other. Take two circles of canvas, each padded with a layer of wadding; tack the head-lining over each circle, and quilt with the machine, each piece in one direction only.

Place one piece of canvas and lining above, and one below. Mark the size of the head-line. Cut out carefully, allowing ½ in. turning beyond the head-line, one piece of lining, one of canvas, and one of material.

Machine-stitch round outer edge, which can be first corded by placing a crossway piece of material with cord tacked in; place this between the two edges of the material, with the turning to the outside, the cord towards the centre. Keep it in a good shape while doing the outside edge.

The band is made of a strip of buckram, 1 in. to 1½ in. wide, and, in length, the size of head, plus 1 in. for turning. Join in a round, and wire top and bottom. Mull and cover with cloth. Sew the crown to band, and line the band neatly, or machine carefully just above and below the wire of band.

Trim the hat with the ribbon, which usually has the name of a man-of-war stamped on in gilt letters.

A washable man-of-war hat is made in the same way. White drill, piqué, or bengaline is used, and white canvas or linen used for interlining. The band should not be wired, but made of double canvas, covered with drill, cut twice

the width of the band, plus ½ in. turnings. Place the canvas between, tack and turn in the ½ in. turning. Place the crown between, tack and machine-stitch crown to band.

In bengaline or any other white material which can be dry cleaned, the band may be made as in the first method described.

Boy's Tam-o'-shanter. The only measurement required for this is the size of head. The materials required are buckram, ½ yd. each of cloth, muslin, and lining.

Cut circles 14 in. to 18 in. in diameter in material, muslin and lining. Make the band in buckram, 1½ in. wide, joined in a round, wired top and bottom, and mulled.

Pleat on muslin lining, boxpleat centre-front, back and sides, with the remainder of fulness in small pleats between, and pleat or gather the material to it. Mark the halves and quarters, and run in the edge three or four rows of gathers. Line the band, and trim it with ribbon, rosettes, quills, or tip.

The elastic for boys' hats must not be forgotten.

Girls' Liberty Hats. Liberty hats are made of Liberty or Japanese silk. A fair sized hat, with frills at edge, will take from 2½ yd. of 36-in.-wide silk. They are exceedingly pretty made in white for young girls' wear. For adults, these gathered and drawn hats can be made in net, plain or spotted, chiffon, and in a variety of other materials.

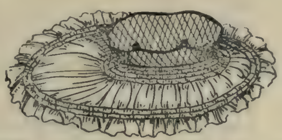
They take 2½ yd. to 3½ yd. of 36-in.-wide silk, a ring of strong white support wire, and one reel of strong machine silk (the ¼ oz. reels are the best), buckram for head-band, stiff muslin or net for the crown, and sarcenet for the head-lining.

The measurements required are the size round head, and, if possible, the diameter of a large hat that suits the girl for whom it is intended.

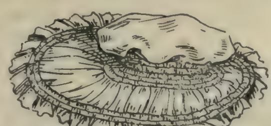
The width of the brim will be according to the size of the head—the larger the head-line, the wider the brim. Little girls have the brim the same size all round. Older girls have the brims made slightly narrower at the back.

Preparation of Silk for Brim. The silk may either be cut on the cross, or straight. The first is better when frills are required at the edge; the latter when more than one hat is to be cut from one length of silk. Silk on the straight is also easier to manipulate and join. The length will be two and a half times the circumference of hat.

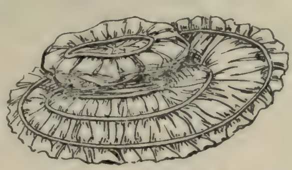
To allow of its being made up double, cut the silk twice the width of the brim. Allow ½ in. extra for each tuck, and double the width of each frill at the edge. Join it in a round and press all the seams *in one direction.* Mark the half and quarters. Fold in half and tack the raw edges together.



187. BRIM WITH NARROW BACK



188. THE TAM-O'-SHANTER CROWN



189. DRAWN SILK HAT

Mark with lillikins the width of frill, 1 in. to 2 in. round edge. If a double frill is required at the edge, pin and tack. Mark ¼ in. away from first marking—this will be for the first casing.

The space between the two lines of running must be just wide enough to allow the wire to pass through double at its end [186]. If made wider, the gatherings will not look well when drawn up. If made narrower, the wire doubled at the end will not pass through, and it will give a great deal of trouble to finish off. Mark the remainder of brim, leaving 1 in. to 1½ in. plain between each casing. The last casing must be about 1 in. from head-line. Thread the needle with strong machine silk, using it from the reel, as it is less likely to get knotted or broken. and fly-run the whole length, beginning from the back.

Pull the silk out to its full length before cutting the twist. Fly-run the other casings in the same way.

Wiring the Brim. To wire the brim, cut off the wire for head-line, plus 2 in. for wrapping. Allow plenty of wire for each casing, and 10 in. extra in length for each 1 in. space left between the casings. Bend round the wire ¼ in. at end, and bind it with cotton to prevent the silk filament from slipping. Then, from the back, make a little cut in the silk, or undo a few stitches in the seam. Push in for a few inches each wire as it is cut off, to prevent the different lengths from getting mixed. Push in the wires, *all at the same time,* in the direction the seams have been pressed.

Join the head-wire first, overlapping the wire for 2 in. Stitch through the silk and loop of wire on the underside of brim with strong cotton. Draw some fulness over the wire before joining. Draw up each wire in turn, and stretch the silk quite tight between the wires. Draw up the twist on each side of the wire and fasten off securely.

Brims may be made fuller-looking by running tucks on the upper and under brim. These will be run separately in front of the first row of casing. Hats with brims of this description require little trimming.

For a brim narrower at the back than at the front [187], make a paper pattern with the brim 1 in. to 2 in. narrower at back, graduating the runners from front to back.

Crowns for these brims are generally low and full on a tam-o'-shanter foundation [187]. Make a head-band and pleat a net or leno crown to it of about 14 in. diameter.

For a large tam-o'-shanter crown, a round, cut the same size as brim, including frills, will make the silk for crown in proportion to the brim [188]. This can be left plain or embroidered, or trimmed,

as preferred. Turn it in and gather round the bottom three times and sew to side-bands. This can be tucked in various ways, but the material must be tucked before cutting the circle.

Another method is to use a crossway piece of silk twice the circumference of foundation crown, for which the corners of silk left from the brim can be utilised. Join it in a round, and make the width about 3 in. more than the length from centre to crown to bottom of head-band. Turn in the edge round bottom and fly-run three times. Fly-run along the other cut edge five or seven times.

Draw up each gathering thread at top and secure to crown. The silk at the sides should fall loosely over the net crown. Finish the space in the centre with an appliqué of lace. If a shaped crown is preferred, cut the side-band and tip to shape. Gather the silk to fit side-band and have the tip with full frill round the edge.

Trimming. Make a large bow across the front, of silk, machine-stitched or slip-stitched, or rosettes, one under and one on top of brim. Young children wear strings of chiffon or silk cut on the straight.

If the brim is turned away from the face with a rosette and a tip coming over the brim, the effect is very pretty. A few small daisies or a bunch of forget-me-nots make a change from an all-white hat.

190. THE VERONIQUE BONNET

Hats can be made in velvet in the same way, allowing a little less for fulness, to keep them light. Velvet hats made over a sparterie shape, with gauged lining, trimmings, and strings of chiffon or crêpe-de-Chine, make becoming children's hats.

Drawn hats in glacé, taffeta silk, or net, are most effective made with raised casings [**189**]. For these, cut three lengths on the cross, 3½ in. wide. Join and machine-stitch one edge, making a narrow hem. Valenciennes or imitation Maltese lace, about 1 in. wide, can be stitched on at the same time. This is for the frill. Cut three strips 9 in. through on the cross. Join, and press the seams all one way. Make a narrow hem on one side and machine-stitch it. Make a tuck 2½ in. from the edge that has been machine-stitched. Then make three more tucks, leaving 1 in. between.

Push the wire into the tucks, fasten securely in the same manner as for a drawn hat, and pull up the twist. Make the head-band and crown. Halve and quarter the 3½-in. strip of silk ; gather and sew on near the first tuck at the edge to make a double frill there.

Line with gauged chiffon, leaving a heading of about 1½ in. Trim with chiffon strings, tucked and gathered at the ends, chiffon rosettes, and tip or small daisies.

These hats may be made of net or chiffon, with raised casing. Push in the satin wire, and finish the edge with rows of straw or crinoline.

Girls' Hats. Girls' school hats in cloth or velvet are made in the same way as described in Shape Making and Covering [p.4768]. Children's straw hats are made the same way as those for adults. As a rule, young girls look best in a large hat with simple trimming, such as a wide bow across the front, rosettes, or, for summer hats, floral mounts, and so on.

Children's Bonnets. Large bonnets [**190**] in straw, of the Veronique type, close-fitting at the back, with full frill in front, can be made in silk or straw. The straw is worked in three pieces, and the back is started by sewing two pieces of straw together and working another two or three rows till the size of the pattern is attained.

Work the front on to this, cutting each row and leaving the straw of the outside long enough to go round back, and finish at the other ear. Make a long straight piece of straw by sewing several lengths together, and pleat this to front of bonnet. The fronts are often curved, in which case make a paper pattern and sew the straw to that shape.

Line with gauged chiffon or silk muslin, and trim with rosettes, flowers, or ribbons. Such bonnets, of course, have strings. Older girls sometimes have ribbon strings tied behind, hanging down the back instead of being fastened under the chin, although the style is not becoming to every type of face.

Continued

THE PARABOLA

Chord Prope: ties. The Ordinate. The Diameter. Parameter of the Diameter. The Central Conics. Focal Distances of a Point on the Curve

continued from page 5784

By HERBERT J. ALLPORT, M.A.

THE PARABOLA

A *Diameter* of a conic is the locus of the middle points of a number of parallel chords. The diameters of conics can be proved to be straight lines.

One diameter is *conjugate* to another when it bisects chords parallel to the other.

The *Ordinate* of any point *to any diameter* is the line drawn to the diameter from the point, parallel to the conjugate diameter.

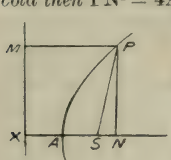
The *Parameter* of a diameter of a parabola is the focal chord which the diameter bisects.

The *Subtangent* at any point is that portion of the axis which lies between the tangent and the ordinate of the point.

The *Subnormal* is that portion of the axis between the normal and the ordinate.

Proposition 78

If PN *is the ordinate of a point* P *on a parabola then* $PN^2 = 4AS \cdot AN$.



For

$PN^2 + SN^2 = SP^2$ (*Prop.* 34)
$= PM^2$ (*Def. of parabola*)
$= XN^2$.

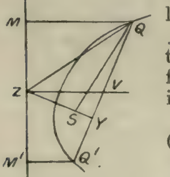
$\therefore PN^2 + (AN - AS)^2 = (AN + AS)^2 = (AN - AS)^2 + 4 AS \cdot AN$.

Hence, $PN^2 = 4 AS \cdot AN$.

Proposition 79

The locus of the middle points of any number of parallel chords of a parabola is a straight line parallel to the axis.

Let QQ′ be one of the || chords. Then, since QQ′ is a *fixed direction*, the line ZSY drawn through S ⊥ to QQ′ will meet the directrix in a *fixed* point Z. Therefore the line ZV, || to the axis, is a fixed straight line.



Now, $ZM^2 = ZQ^2 - QM^2$ (*Prop.* 34) $= ZQ^2 - SQ^2 = (ZY^2 + YQ^2) - (SY^2 + YQ^2) = ZY^2 - SY^2$.

Similarly, $ZM'^2 = ZY^2 - SY^2$.

$\therefore$ ZM = ZM′, and hence QV = Q′V (*Prop.* 27).

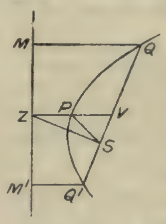
Thus, ZV, a line || to the axis, bisects QQ′, a chord ⊥ to ZS. In the same way ZV bisects all other chords ⊥ to ZS.

Proposition 80

The parameter of any diameter of a parabola is four times the focal distance of the end of the diameter.

Let the diameter PV meet its parameter QSQ′ in V, and the directrix in Z. Then ZSQ is a right ∠ (*Prop.* 79).

Since SP = PZ, ∠SZP = ∠ZSP.



$\therefore$ their complements are equal.

$\therefore$ ∠SVP = ∠PSV.

$\therefore$ SP = PV.

Hence,

ZV = 2 SP.

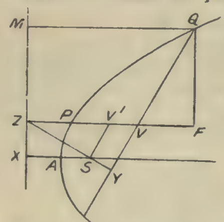
Now, since ZM = ZM′, and MQ, ZV, M′Q′ are ||s, it can easily be proved that MQ + M′Q′ = 2 ZV. But, by the definition of a parabola, MQ + M′Q′ = SQ + SQ′ = QQ′.

$\therefore$ QQ′ = 2 ZV = 4 SP.

Proposition 81

If QV *be the ordinate of any diameter* PV, *then* $QV^2 = 4 SP \cdot PV$.

Let PV meet its parameter in V′ and the directrix in Z. Then ZS is ⊥ to SV′ and QV. Draw QF ⊥ to PV.



Then $QF^2 = MZ^2 = ZY^2 - SY^2$ (*Prop.* 79).

But, by similar Δs,

$$\frac{QF}{QV} = \frac{ZY}{ZV} = \frac{SY}{V'V}.$$

$\therefore QV^2 = ZV^2 - V'V^2$.

But SP = PZ = PV′ (*Prop.* 80).

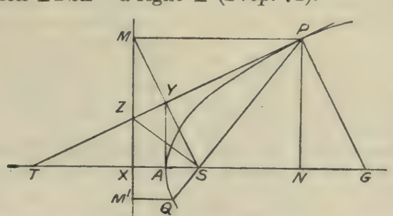
$\therefore$ ZV = PV + SP, and V′V = PV − SP.

$\therefore QV^2 = (PV + SP)^2 - (PV - SP)^2$
$= 4 SP \cdot PV$ [*Art.* 60, page 2749].

Proposition 82

The tangent at any point of a parabola bisects the angle between the focal distance of the point and the diameter produced.

Let the tangent at P meet the directrix in Z. Then ∠PSZ = a right ∠ (*Prop.* 72).



Hence, the right-angled Δs PSZ, PMZ have a common hypotenu-e, and the side SP = side PM.

$\therefore$ ∠SPZ = ∠MPZ (*Prop.* 20).

Corollary 1. ∠STP = ∠TPM (*Prop.* 12) = ∠SPT.

$\therefore$ ST = SP = PM = XN.

$\therefore$ ST − AS = XN − AX ;

or $\quad AT = AN.$

$\therefore NT = 2\ AN.$

Hence, *the subtangent is twice* AN.

Corollary 2. If PQ is a focal chord, and PM, QM′ are $\perp$ to the directrix, then the tangent at P bisects the $\angle$SZM, and the tangent at Q bisects the $\angle$SZM′.

$\therefore$ PZQ is half the sum of $\angle$s SZM, SZM′.

$\therefore \angle$PZQ is a right $\angle$.

Hence, *tangents at the ends of a focal chord meet at right angles in the directrix.*

Corollary 3. Let PG be the normal at P. Then, since $\angle SPT = \angle STP$.

$\therefore$ their complements are equal.

$\therefore \angle SPG = \angle SGP.$

$\therefore SG = SP = PM = XN.$

$\therefore$ subtracting SN, we have $NG = SX = 2\ SA$; or, *the subnormal is equal to the semi-latus-rectum.*

Proposition 83

If Y *is the foot of the perpendicular from the focus on the tangent at* P, *then* Y *lies on the tangent at the vertex, and* $SY^2 = SA \cdot SP$.

Draw the tangent at the vertex, and let it meet PT in Y [see figure of *Prop.* 82]. Join SY. Then AN = AT (*Prop.* 82).

$\therefore$ YP = YT (*Prop.* 26).

$\therefore$ Δs SPY, STY have the sides SP, PY equal to ST, TY and the $\angle SPY = \angle STY$.

$\therefore$ Δs are equal.

$\therefore \angle SYP = \angle SYT$ and each is a right $\angle$.

Thus, the tangent at the vertex passes through the foot of the perpendicular drawn from S to the tangent at P.

Again, YA, YP subtend equal angles at the focus (*Prop.* 74).

And right $\angle SAY$ = right $\angle SYP$.

$\therefore$ Δs SAY, SYP are similar.

$\therefore SA : SY = SY : SP;$

or $SY^2 = SA \cdot SP.$

CENTRAL CONICS

It has already been shown that central conics have two vertices. They also have two foci. If A, A′ are the vertices, S a focus, and X the point in which the axis meets the directrix, then, by making A′S′ equal to AS, and A′X′ equal to AX, the curve can equally well be described by using S′ as focus, and a line through X′, perpendicular to XX′, for directrix.

In a central conic, AA′ is called the

transverse axis; while the straight line through the centre, perpendicular to AA′, is called the *conjugate* axis.

Segments of the Transverse Axis.

In an ellipse, whose focus is S and vertices A and A′, we have

$$SA' : A'X = SA : AX.$$

$$\therefore SA' : SA = A'X : AX,$$

and $\quad SA' + SA : SA = A'X + AX : AX,$

i.e., $\quad AA' : SA = XX' : AX.$

$$\therefore CA : CX = SA : AX. \quad . \quad . \quad (1)$$

Again, $\quad SA' - SA : SA = A'X - AX : AX,$

i.e., $\quad SS' : SA = AA' : AX.$

$$\therefore CS : CA = SA : AX. \quad . \quad . \quad (2)$$

Hence, from (1) and (2)

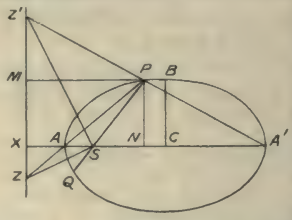
$$CS : CA = CA : CX;$$

so that $CS \cdot CX = CA^2$.

In a similar way, the same result can be proved for the hyperbola.

Proposition 84

In a central conic, if PN *be the ordinate of any point* P *on the curve, then the ratio* $PN^2 : AN \cdot A'N$ *is constant.*



Let AP and A′P, or these lines produced, meet the directrix in Z and Z′. Join SZ, SZ′. and draw PM $\perp$ to the directrix.

Then $\quad SP : PM = SA' : A'X$ (*Def. of a conic*).

$\therefore SP : SA' = PM : A'X$

$= PZ' : A'Z'$ (*Prop.* 56).

$\therefore$ SZ′ bisects the $\angle$PSX (*Prop.* 55).

Similarly, SZ bisects the $\angle$ QSX

$\therefore$ ZSZ′ is a right $\angle$.

$\therefore ZX \cdot Z'X = SX^2$ (*Prop.* 60, *Cor.*).

Again, by similar triangles,

$$PN : AN = ZX : AX$$

and $\quad PN : A'N = Z'X : A'X.$

$$\therefore PN^2 : AN \cdot A'N = ZX \cdot Z'X : AX \cdot A'X$$

$$= SX^2 : AX \cdot A'X.$$

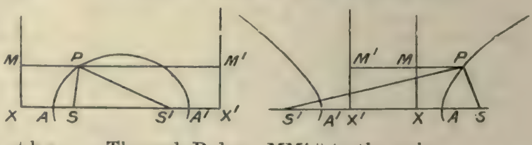
But SX, AX, A′X are all fixed. Therefore $PN^2 : AN \cdot A'N$ is constant.

Corollary. Let CB be $\perp$ to CA. Then, if P be taken in the position B, the ratio $PN^2 : AN \cdot A'N$ becomes $BC^2 : AC^2$; so that, in an ellipse, $PN^2 : AN \cdot A'N = BC^2 : AC^2$.

In the hyperbola, the conjugate axis does not meet the curve, but if BC is of such a length that $BC^2 : AC^2 = SX^2 : AX \cdot A'X$, BC is still called the semi-conjugate-axis.

Proposition 85

The sum, or the difference of the distances from the foci of any point on a central conic is constant, and equal to the transverse axis.



Through P draw MM′ ∥ to the axis.

Then $SP : PM = S'P : PM' = e$, where e equals the eccentricity.

$\therefore SP = e \cdot PM$, and $S'P = e \cdot PM'$.

$\therefore$ in the ellipse, $SP + S'P = e\,(PM + PM')$

$= e \cdot MM' = e \cdot XX'$,

and, in the hyperbola,

$S'P - SP = e\,(PM' - PM)$

$= e \cdot MM' = e \cdot XX'$.

Hence, in the ellipse the *sum* of the focal distances is constant, and in the hyperbola their *difference* is constant. By taking P in the position A, it is evident that this constant quantity is AA′, the transverse axis.

GEOMETRY *concluded; followed by* TRIGONOMETRY

ITALIAN

Continued from page 5651

By Francesco de Feo

CONJUNCTIONS—continued

Different Meanings of Conjunctions

THE same conjunction may be used to indicate different relations, as will be seen from the following examples:

Che. The conjunction *che* may be used with the meanings:

1. FINAL: *Accendete il lume,* CH'*io possa vedère,* Light the lamp, that I may be able to see; *Parlate ad alta voce,* CHE *tutti capiscano,* Speak aloud, that all may understand.

2. CAUSAL: *Son contento* CHE *sei venuto a casa presto,* I am pleased that you have come home early; *Chiudete la finestra,* CHE *fa troppo freddo,* Shut the window, because it is too cold.

NOTE. The *che* (final or causal) may also be written with a grave accent.

3. TEMPORAL: *Venne a casa* CHE *èrano già le ùndici,* He came home when it was already eleven; *Sono quindici giorni* CHE *piove sempre,* It has been raining for a fortnight.

4. CONSECUTIVE: *Quel signore parla* CHE *non si capisce,* That gentleman speaks so that one cannot understand him; *Questa valìgia è così pìccola,* CHE *non c'entra niente,* This portmanteau is so small that nothing will go into it.

The conjunction *che,* in subjective or objective propositions, may be sometimes omitted: *Sembra* (*che*) *non ci sia altro,* It seems that there is nothing else; *Temo* (*che*) *non rièsca a convìncerlo,* I fear that he will not succeed in convincing him.

It is, however, a rule to omit the *che* in propositions preceded by another *che*: *Prese le quattro pòvere bèstie, e le diede a Renzo, con un'occhiata di compassione che pareva* (CHE) *volesse dire*: *bisogna che tu l'àbbia fatta bella,* She took the four poor beasts and gave them to Renzo, with a pitiful look, which seemed to mean, "You must have done something serious."

The *che* united to adverbs, prepositions, or other words, in compound conjunctions may be sometimes understood. *Le scrivo sùbito, acciò* (CHE) *sàppia come regolarsi,* I am writing you at once, in order that you may know how to conduct yourself.

The *relative che* can never be omitted in Italian, as is often done in colloquial English: *I libri che abbiamo comprato,* The books (that) we have bought; *Le due sterline che mi prestaste,* The two pounds (that) you lent me.

The conjunction *che* preceded by the negation *non* (*non che*) is translated in English by "far from," "not to speak of," "to say nothing of," and similar expressions: *Don Abbòndio, non che pensare a trasgredire una tal legge, si pentiva anche dell' avèr ciarlato con Perpètua,* Don Abbondio, far from thinking of transgressing such a law, even repented that he had spoken with Perpetua.

E. The copulative conjunction *e* may also be used with an adversative meaning, as: *Disse che sarebbe venuto e* (*ma*) *non è venuto,* He said he would come, but he has not; *Dovevo scrìvergli e* (*ma*) *non gli ho scritto,* I had to write to him, and (but) I have not written.

Sometimes the conjunction *e* is used with the meaning of *anche* (also): *Se io parlo, e lui parla; se io sto zitto, e lui sta zitto,* If I speak, he also speaks; if I am silent, he also is silent.

The English expressions *so do I, so do we, so am I, neither do I,* etc., are rendered in Italian by (*e*) *anch'io,* etc.; (*e*) *nemmeno io,* etc. Examples: I am hungry—so am I, *Io ho fame—anch'io*; I don't believe it—neither do I, *Io non ci credo—nemmeno io.*

Se. The conjunction *se* (and sometimes also the adverb *come*) may be used instead of *che*: *Scuserai se non te l'ho scritto prima,* You will excuse me if I have not written it to you before; *Mi hanno raccontato come tutto sia finito tra voi due,* They have told me that everything is over between you two.

Perchè. *Perchè* is often used instead of *affinchè,* in order that: *Avvicinàtevi perchè io possa vedèr meglio,* Come near, so that I may see better.

ESERCIZIO DI LETTURA—continued

A siffatta[1] proposta, l'indignazione del frate, rattenuta a stento fin allora, traboccò. Tutti quei bei proponimenti di prudenza e di pazienza andàrono in fumo[2]: l'uomo vecchio si trovò di accordo col nuovo; e, in quei casi, fra Cristòforo valeva veramente per due.

"La vostra protezione!" esclamò, dando indietro due passi, postàndosi fieramente sul piede destro, mettendo la destra[3] su l'anca, alzando la sinistra[4] con l'ìndice teso verso don Rodrigo, e piantàndogli in fàccia due occhi infiammati: "la vostra protezione! È meglio che abbiate parlato così, che abbiate fatta a me una tale proposta. Avete colmato[5] la misura e non vi temo più."

"Come parli, frate?"

"Parlo come si parla a chi è abbandonato da Dio, e non può più far paura. La vostra protezione! Sapevo bene che quella innocente è sotto la protezione di Dio; ma voi, voi me lo fate sentire ora, con tanta certezza, che non ho più bisogno di riguardi a parlàrvene. Lucia, dico: vedete come io pronùnzio questo nome con la fronte alta, e con gli occhi immòbili."

"Come! in questa casa . . . !"

"Ho compassione di questa casa; la maledizione le sta sopra sospesa. State a vedère che la giustizia di Dio avrà riguardo a quattro pietre e suggezione di quattro sgherri. Voi avete creduto che Dio àbbia fatta una creatura a sua immàgine, per darvi il piacere di tormentarla! Voi avete creduto che Dio non saprebbe difènderla! Voi avete disprezzato il suo avviso! Vi siete giudicato. Il cuore di Faraone era indurito quanto il vostro; e Dio ha saputo spezzarlo. Lucia è sicura da voi[6]: ve lo dico io pòvero frate; e in quanto a voi, sentite bene quel ch'io vi prometto: Verrà un giorno . . . "—continued.

NOTES. 1. such; 2. *andare in fumo,* to vanish away; 3. right hand; 4. left hand; 5. fitted up; 6. is safe from you.

IRREGULAR VERBS

Third Conjugation

Apparire, to appear

Ind. Pres.—Apparisco (*appàio*), *apparisci* and *appari*, *apparisce* and *appare*, *appariamo*, *apparite*, *appariscono* and *appàiono*.

Past Def.—Apparvi, apparsi and *apparii* (regular); *apparve, apparse* and *apparì* ; *appàrvero, appàrsero* and *apparìrono*.

Subj. Pres.—Apparisca and *appàia*, etc., third person plural: *apparìscano* and *appàiano*.

Imperat.—Apparisci, apparisca, etc.

Past Part.—Apparso.

Pres. Part.—Apparente.

Comparire, to appear

Pres. Ind.—Comparisco, comparisci, comparisce, etc. [see *apparire* above].

Cucire, to sew

This verb preserves the soft sound of the *c* throughout the conjugation.

Ind. Pres.—Cùcio, cuci, cuce, cuciamo, cucite, cùciono.

Past Def.—Cucii, cucisti, etc.

Subj. Pres.—Cucia, cùcia, etc.

Imperat.—Cuci, cùcia, etc.

Inserire, to insert

Pres. Ind.—Inserisco, inserisci, etc.

Past Def.—Inserii, inseristi, etc. (regular).

Past Part.—Inserito (*inserto*).

Morire, to die

Ind. Pres.—Muòio, muoro (*mòio*) ; *muori* (*mori*), *muore* ; *moriamo, morite, muòiono* (*mòiono*).

Imperf.—Morivo, etc.

Past Def.—Morii, moristi, etc.

Future—Morirò or *morrò, morirai* or *morrai, morirà* or *morrà*, etc.

Subj. Pres.—Muòia (*mòia*), etc.

Imperat.—Muori, muòia, etc.

Condit.—Morirei and *morrei*, etc.

Past Part.—Morto.

Pres. Part.—Morente (*moriente*).

Gerund.—Morendo.

Note. This verb, when conjugated with the auxiliary *avère*, to have, means to kill.

Percepire, to conceive

Ind. Pres.—Percepisco, percepisci, etc.

Past Part.—Percepito (*percetto*).

Scalfire, to scratch

Pres. Ind.—Scalfisco, scalfisci, etc.

Past Part.—Scalfitto.

Scomparire, to disappear [see *apparire*]

Scucire, Sdrucire, to unsew [see *cucire*]

Seppellire, to bury

Pres. Ind.—Seppellisco, etc.

Past Part.—Sepolto (*seppellito*).

Sparire, to disappear

Ind. Pres.—Sparisco, sparisci, sparisce, etc.

Past Def.—Sparii (*sparvi*), etc.

Past Part.—Sparito.

Trasparire, to be transparent [see *sparire*, above].

Udire, to hear

Ind. Pres.—Odo, odi, ode, udiamo, udite, òdono.

Imperf.—Udivo, udivi, etc.

Past Def.—Udii, udisti, udì, etc.

Future—Udirò and *udrò, udirai* and *udrà, udiremo* and *udremo*, etc.

Subj. Pres.—Oda, oda, oda, udiamo, udiate, òdano.

Imperat.—Odi, oda, udiamo, udite, òdano.

Condit.—Udirei and *udrei*, etc.

Past Part.—Udito.

Pres. Part.—Udente (*udiente*).

Gerund.—Udendo.

Note. The verb *udire* changes the vowel *u* into *o* when the accent falls on the first syllable. Thus: *Odo, òdi*, but *udiàmo, udìte.*

Uscire, to go out

Ind. Pres.—Esco, esci, esce, usciamo, uscite, èscono.

Imperf.—Uscivo, uscivi, etc.

Past Def.—Uscii, uscisti, uscì, etc.

Future—Uscirò, etc.

Subj. Pres.—Esca, esca, esca, usciamo, usciate, èscano.

Imperat.—Esci, esca, usciamo, uscite, èscano.

Condit.—Uscirei, etc.

Past Part.—Uscito.

Note. The verb *uscire* changes the vowel *u* into *e* when the accent falls on the first syllable. Thus: *Esco, èsci*, but *usciàmo, uscìte.*

Conjugate like *uscire* : *Riuscire*, to succeed.

Venire, to come

Ind. Pres.—Vengo, vieni, viene, veniamo, venite, vèngono.

Past Def.—Venni, venisti, venne, venimmo, veniste, vènnero.

Future—Verrò, verrai, verrà, verremo, verrete, verranno.

Subj. Pres.—Venga, venga, venga, veniamo, veniate, vèngano.

Imperat.—Vieni, venga, veniamo, venite, vèngano.

Condit.—Verrei, verresti, verrebbe, etc.

Past Part.—Venuto.

Pres. Part.—Veniente.

Conjugate like *venire* : *avvenire*, to befall; *convenire*, to suit; *divenire*, to become; *pervenire*, to attain; *sopravvenire*, to happen; *prevenire*, to come before, to anticipate; *provenire*, to derive; *rinvenire*, to recover.

Exercise LIV.

1. Essi appàrvero vestiti in una maniera così strana, che tutti cominciammo a rìdere. 2. Abbiamo comprato una nuova màcchina da cucire. 3. L'impressione ch' egli ricevette dal vedèr l'uomo morto per lui, e l'uomo morto da lui, fu nuova e indicìbile. 4. Datemi qualche cosa da mangiare, perchè muòio di fame. 5. Il vostro servo dev' èssere un buon uomo, l' ho sempre udito lodare da tutti. 6. Non sono riuscito a capire una parola di quello che ha detto. 7. Se non piove usciremo anche noi. 8. Non ho mai udito una cosa sìmile ! 9. I bottoni delle mie camìcie si sono tutti staccati, vi prego di cucirli meglio la pròssima volta. 10. Non so capire perchè non sia venuto ancòra.

Conversazione

Perchè gli avete dato il permesso di uscire ?

Io non gli ho dato nessun permesso ; è uscito a mia insaputa (*without my knowing it*).

Quando siete arrivato ?

Sono arrivato stamattina, e ripartirò stasera col treno delle nove e quarantacinque.

È venuto nessuno durante la mia assenza ?

È venuto quel signore tedesco, e ha lasciato una lèttera per voi.
Perchè la signora N. non era al ballo l' altra sera ?
Perchè è in lutto (*mourning*) ; non è nemmeno un mese che le è morto il padre.
Io muòio di freddo.
Venga nella mia càmera ; c' è un bel fuoco.
Aspetti ch' àbbia finito.

KEY TO EXERCISE LII.

1. My brother and sister have arrived to-day from Paris. 2. Why did you not come to the station ? 3. Because we have not been able to find a carriage. 4. Do not go away ; wait till I come back. 5. If my father would permit me, I should come willingly. 6. My watch costs twice as much as yours ; that is one hundred and twenty francs. 7. I have forgotten to take my ticket, therefore I have not been able to enter. 8. I should go there, if I had time and money. 9. I have called you twice, but you have not answered me. 10. He never gave himself the trouble of returning me the money that he owes me, though I asked him for it several times. 11. I have sent him a registered letter, so he cannot say that he has not received it. 12. If you had arrived before, it would have been much better.

KEY TO EXERCISE LIII.

1. Give me a match, please ; my cigar has gone out. 2. Do not let the fire go out, because we shall return home soon. 3. The enemy has been repulsed, but with heavy losses on our side. 4. I am convinced that things are as you say. 5. I will give you a very interesting novel translated from English. 6. What do you advise me, to translate from Italian into English, or from English into Italian ? 7. They knew each other three years ago in Florence, and since then they have always lived together. 8. The affair seemed almost concluded, but lately such and so many difficulties have arisen, that they have deprived me of all hope. 9. This is a good chance for him ; we shall see whether he will this time know how to take advantage of it. 10. He has gone to America, attracted thither by the hope of great gains. 11. That friend of mine who succeeded in winning a huge fortune at Monte Carlo has ended by losing his last halfpenny. 12. " This is the fable," said the old man, shaking his head ; " you draw the moral out of it."

Continued

FRENCH

Continued from page 5802

By Louis A. Barbé, B.A.

VERBS

Agreement with a Simple Subject

1. Every verb in a finite tense agrees with its subject in number and person : *Le cœur d'une mère est le chef-d'œuvre de la nature,* A mother's heart is Nature's masterpiece.

2. When a verb has for its subject a collective noun, or noun of multitude, followed by another noun in the plural as its complement, that verb is in the singular or in the plural, according as the leading idea is expressed either by the collective or by its complement : *Une nuée de sauterelles obscurcit l'air,* A cloud of locusts obscured the air ; *Une nuée de barbares désolèrent le pays,* A cloud of barbarians laid waste the country.

3. After *la plupart,* whether a plural complement is actually expressed or only understood, the verb is always in the plural : *Quand on en vint aux voix, la plupart se déclarèrent de mon avis,* When it came to voting, the greater number declared themselves of my opinion.

4. After the adverbs of quantity, *peu, beaucoup, moins, assez, trop,* followed by a plural, the verb is always in the plural : *Beaucoup de gens promettent ; peu savent tenir,* Many people promise ; few know how to keep (their promises).

5. When *peu* is preceded by *le,* the verb is in the singular if *le peu* expresses want or deficiency : *Le peut de gens avec qui on peut communiquer des sciences abstraites m'en avait dégoûté,* The few (= the lack of) people with whom one can discuss the abstract sciences had put me out of conceit with them.

When *le peu* expresses a small quantity, or a small number, the verb agrees with the noun following it : *Le peu d'amis que j'avais sont venus à mon secours,* The few friends I had have come to my help.

6. *Plus d'un,* though expressing plurality, requires the verb that follows it to be in the singular : *Plus d'un doit son succès à sa persévérance autant qu' à son talent,* More than one owes his success to his perseverance as much as to his talent.

7. The verb of which *tout le monde* is the subject is always in the singular : *Tout le monde est sujet à l'erreur,* Everybody is liable to error.

8. When preceded by *ce,* the verb *être* is in the third person singular if it is followed by a plural pronoun of the first or of the second person, or by two or more nouns in the singular : *C'est nous qui avons le plus souffert de sa tyrannie,* It is we who have suffered most from his tyranny.

9. Though preceded by *ce,* the verb *être* requires to be in the plural ; if it is followed by a plural noun or by a personal pronoun in the third person plural : *Ce furent les Phéniciens qui inventèrent l'écriture,* It was the Phœnicians who invented writing.

10. When the verb *être* preceded by *ce* is followed by two (or more) substantives of which one is singular and the other plural, it takes the number of the substantive nearest to it : *Ce sera le même théâtre et les mêmes décorations,* It will be the same theatre and the same decorations.

11. When the verb *être* preceded by *ce* is equivalent to the impersonal verb *y avoir,* it may, if followed by a plural noun, be either in the singular or the plural itself : *C'était* (or *c'étaient*) *tous les jours de nouvelles plaintes,* There were new complaints every day.

12. The verb *être* preceded by *ce* remains in the singular if it is followed by a noun and a numeral adjective which, though plural in form, convey an idea of unity, and may be replaced by the singular : *C'est quatre heures qui sonnent,* It is four o'clock that is striking—that is to say, *la quatrième heure,* the fourth hour.

Agreement with Several Subjects

1. When the subject of a verb consists of several nouns or pronouns in the singular, the verb itself is in the plural : *L'hirondelle et le rossignol annoncent le retour du printemps,* The swallow and the nightingale announce the return of spring.

2. When the various parts of the subject are not of the same person, the verb is in the plural and

agrees with the person that has priority. In that case, it is usual, but not essential, to introduce an additional plural pronoun representing that person: *Vous et moi (nous) sommes contents de notre sort,* You and I are content with our lot.

3. The verb may be in the singular when the various nouns of which the subject consists are practically synonymous.

4. When two subjects are joined either by *ni* or by *ou*, the verb is usually in the plural, unless it is obvious that one subject excludes the other: *Ni l'or ni la grandeur ne nous rendent heureux,* Neither gold nor greatness make us happy. *Ni Corneille ni Racine n'est l'auteur de ces vers,* Neither Corneille nor Racine is the author of those verses.

5. A verb having *l'un et l'autre* for its subject must be in the plural: *L'un et l'autre rapportent les mêmes circonstances,* The one and the other (= both) record the same circumstances.

Complement of the Verb

1. The same noun may be the complement (or object) of two verbs, provided both verbs govern the same case: *Les enfants doivent aimer et respecter leurs parents,* Children should love and respect their parents. Here, *parents* is the direct object (or accusative) of both *aimer* and *respecter.* It is incorrect to say: *Les enfants doivent obéir et respecter leurs parents,* because *obéir* requires an indirect object (or dative), whilst *respecter* governs a direct object (or accusative). The proper construction is: *Les enfants doivent obéir à leurs parents et les respecter,* Children must obey their parents and respect them.

2. When a verb has several complements joined by *et, ou,* or *ni,* all these complements must be of the same kind—*i.e.*, either all nouns, or all infinitives, etc.; but not one noun and one infinitive: *Il aime le chant et le dessin,* He likes singing and drawing; *Il aime à chanter et à dessiner,* He likes to sing and to draw.

Both these sentences are correct; but it would be incorrect to say: *Il aime le chant et à dessiner,* He likes singing and to draw.

3. If a verb has both a direct and an indirect complement, the direct complement (or accusative) comes first, provided both are of equal length: *On doit préférer la mort à l'esclavage,* We should prefer death to slavery.

4. If the two complements are of unequal length, the shorter usually comes first: *L'avare sacrifie à l'intérêt son honneur et sa vie,* The miser sacrifices honour and life to interest.

Use of Auxiliaries

1. All transitive verbs take *avoir* for their auxiliary: *J'ai donné; tu avais fini; il aura reçu; vous auriez vendu.*

2. Most intransitive verbs take *avoir* for their auxiliary: *Il a succombé; elle avait régné.*

3. All reflexive verbs are conjugated with *être* in their compound tenses: *Je me suis blessé; vous vous seriez aperçus.*

4. The passive voice consists throughout of the verb *être* with a past participle added to it: *Il est aimé; ils ont été battus.*

5. The following intransitive verbs are always conjugated with *être*:

Aller, to go; *arriver,* to arrive; *choir,* to fall; *décéder,* to die; *échoir,* to fall due; *éclore,* to be hatched, to blossom; *entrer,* to enter; *mourir,* to die; *naître,* to be born; *repartir,* to set out again; *ressortir,* to go out again; *retourner,* to go back; *venir,* to come; and the derivatives *rentrer,* to come back, to re-enter; *devenir,* to become; *intervenir,* to intervene; *parvenir,* to succeed, to attain to; *provenir,* to proceed from; *redevenir,* to become again.

6. A certain number of intransitive verbs, though almost always conjugated with *être,* are occasionally to be found conjugated with *avoir.* They are:

Descendre, to go down; *monter,* to go up; *partir,* to set out, to go off; *retomber,* to fall again; *tomber,* to fall.

7. Any intransitive verb used transitively requires *avoir* for its auxiliary: *Avez-vous descendu nos bagages?* Have you taken down our baggage?

8. A certain number of verbs, of which the following are the chief, are conjugated with *avoir* or with *être,* according as they denote action or state resulting from action:

Accourir, to run up; *cesser,* to cease; *changer,* to change; *croître,* to grow; *déborder,* to overflow; *dégénérer,* to degenerate; *disparaître,* to disappear; *échouer,* to run aground, to fail; *embellir,* to become handsomer; *grandir,* to grow up; *grossir,* to increase in size; *maigrir,* to become thinner; *passer,* to pass; *rajeunir,* to become young again; *vieillir,* to grow old. *Cet enfant a bien grandi en peu de temps,* That child has grown a great deal in a short time. *Comme il est grandi!* How grown (= tall) he is!

9. Some verbs have different meanings, according as they are conjugated with *avoir* or with *être.* Such are, *Convenir,* to suit, to agree: *Cette maison nous a convenu,* That house has suited (pleased) us. *Nous sommes convenus d'acheter cette maison,* We have agreed to buy that house.

Demeurer, to dwell, to stop: *Il a demeuré longtemps à Paris,* He lived a long time in Paris. *L'affaire en est demeurée là,* The matter stopped there.

Échapper, to escape notice, to be forgotten, to slip from, to be said unwittingly: *Ce que je voulais vous dire m'a échappé,* What I wished to tell you has escaped me (*i.e.*, my memory). *Il lui est échappé un mot qu'il ne voulait pas dire,* A word he did not wish to say has escaped him.

Use of the Subjunctive

1. The verb of the subordinate clause must be in the subjunctive when the verb of the principal clause expresses surprise, admiration, wish, consent, prohibition, doubt, fear, command: *Je m'étonne qu'il ne voie pas le danger où il est,* I am astonished that he does not see the danger in which he is.

2. The verb of the subordinate clause must be in the subjunctive when the verb of the principal clause is either negative or interrogative: *Je n'ai employé aucune fiction qui ne soit une image sensible de la vérité,* I have used no fiction but is a sensible image of truth. *Croyez-vous qu'il vienne?* Do you think he will come?

Exception: When the interrogation is merely formal, and really amounts to a direct statement, the subjunctive is not required: *Croyez-vous que les Parisiens sont des sots?* Do you think Parisians are blockheads?

3. The verb of the subordinate clause must be in the subjunctive after impersonal verbs and phrases: *Il vaut mieux qu'il ne vienne point,* It is better he should not come. *Il importe que vous y soyez,* It is important that you should be there.

Exception: (*a*) The indicative is required after *il s'ensuit,* it follows; *il résulte,* it results; *il arrive,* it happens; and after impersonal phrases in which there occurs an adjective expressive of certainty, such as *évident, sûr, certain, vrai,* except when these are either negative or interrogative:

Il arrive souvent qu'on est trompé, It often happens that we are mistaken.

(*b*) The verb *sembler,* though used impersonally, requires the indicative if it is preceded by one of the personal pronouns *me, te, nous, vous, lui, leur*; but, if used negatively or interrogatively, it follows the rule: *Il me semble qu'il n'y a pas de plus grande jouissance que celle de faire des heureux,* It seems to me that there is no greater happiness than that of making people happy. *Il ne me semble pas que l'on puisse penser différemment,* It does not seem to me that anyone can think otherwise.

4. The verb of a relative clause must be in the subjunctive if it does not express an actual fact, and if the relative clause implies some purpose regarding the antecedent, or some unattained result. To express what is regarded as a fact or a certain result the indicative is used: *Si je vais à Londres, ce sera avec quelqu'un qui sache parler anglais; Si je vais à Londres, ce sera avec quelqu'un qui sait parler anglais.* Both these sentences mean: If I go to London it will be with someone who can speak English. In the first of them, the use of the subjunctive indicates that such a person has not yet been secured; in the second, the use of the indicative implies that such a person is actually available.

Continued

ESPERANTO

Continued from page 5806

By Harald Clegg

ELISION

The only letters which may be omitted from Esperanto words are the *a* of the article *la* and the final *o* of a substantive, in which case an apostrophe is substituted. In the case of the article, this is only permissible when *la* is preceded by a preposition having a final vowel.

Examples: *La fino de l'jaro,* The end of the year; *Ŝi kantis pri l'amo,* She sang of love.

The *o* in a substantive may only be dropped when such word is singular and in the nominative case. Examples: *Ho mia kor'!* Oh, my heart! *Sinjor' Doktoro,* Mr. Doctor.

As a general rule, and in order to ensure comprehension to a listener, it is certainly advisable to avoid elision altogether. The permission to use elision is freely taken advantage of in writing verse, and this is the only case where such omission is really justified. When, however, elision of the *o* in nouns is resorted to, the accent still remains on the same syllable as before.

Vocabulary

apog', lean, rest
batal', battle, fight
ben', bless
cifer', numerical figure
ĉemiz', shirt
dat', date (time)
depend', depend
diferenc', difference
diligent', diligent
ekzist', exist
fund', bottom
gard', guard (v.t.)
ĝem', groan
ha,* ah
hirund', swallow (bird)
imit', imitate
intern', inner, inside
kajer', paper-covered book
kest', chest, box
komunik', communicate
kovr', cover (v.t.)
kripl', crippled
kuler', spoon
kurb', curved
lag', lake
lip', lip
las', leave, let
martel', hammer (subst.)
menton', chin
miks', mix
miop', short-sighted
naĝ', swim
najl', nail (metal)
nutr', nourish, feed
obe', obey
objekt', object, thing, article
pac', peace
pas', pass (v. i.)
paŝ', step, stride
pere', perish
permes', permit
pinĉ', pinch
plend', complain
pork', pig
posed', possess
poŝ', pocket
preciz', precise, exact
prunt', loan
raz', shave
tas', cup

Exercise XIII.

La riĉulo bone manĝas kaj vivas, sed la malriĉulo nur ekzistas. Paŝo post paŝo la homoj ĉiam antaŭen iras malgraŭ ĉio, kio kontraŭstaras ilin. La kriplulo volis naĝi trans la lagon, sed ĉe la mezo li pereis, kaj subiris ĝis la fundo. Laŭ mia deziro, mia boonklo pruntedonis al mi la keston kaj ĉiujn objektojn, kiujn ĝi enhavis, krom la arĝentaj kuleroj kaj la raziloj. La hirundo rapide flugis preter la rivero. Ĉu vi memoras la daton, kiam feliĉe paco fine okazis? La bonulon oni devus beni kaj imiti. Li alnajlis la kovrilon sur la keston, antaŭ kiam li enmetis la tasojn. La miopulo plendis kontraŭ mi, ĉar mi skribis tre malgrandajn ciferojn. Oni devus honori kaj obei la gepatrojn (or, al la gepatroj). La daton de la letero mi ne certe memoras, sed mi kredas, ke la plendulo skribis gin ĉirkaŭ la kvina de la nuna monato. Li apogis sin sur mian brakon kaj ekĝemis. Mi ankoraŭ ne scias precize, kiom mi posedas en mia poŝo. La homoj ĉiame kontraŭbatalas unu la alian, kaj nur la fortuloj postvivas. Kia estas la diferenco inter ĉi tiu okjekto kaj tiu? Estas nenia. Li jam forlasis la urbon antaŭ kiam mi tie loĝis. Dum mi nutris la porkojn la malriĉulo preterpasis kaj atente rigardis ilin. Anstataŭ paroli, ŝi staris tie kun palaj lipoj kvazaŭ muta. Ĉu mi permesos tion, dependas de lia preciza deziro, sed intertempe vi devas labori diligente kaj havi paciencon.

PRONOUNS

Possessive Reflexive (sia)

The Reflexive Pronoun *Si* has been dealt with and explained on page 4656, but the use of *sia* as a Reflexive Pronoun in place of *lia, ŝia, ĝia* and *ilia* must be carefully marked and learned by the student, in order to avoid causing ambiguity as to the actual possessor of the direct or indirect object in a sentence. Like *si*, from which it is derived, *sia* relates only to the third person whether the number be singular or plural, but it must, of course, like the other possessive pronouns, take the plural and accusative signs, if that which is possessed be plural and in the accusative case.

A few examples of ambiguity in English will most clearly show the importance of the correct use of the reflexive pronoun:

When we say: "John loves Peter and his brother," there is a doubt as to whose brother is referred to. Now, in Esperanto, *sia* always refers to the subject of the clause in which it occurs, and, thus, if we translate the above sentence, *Johano amas Petron kaj sian fraton,* the friend of whom we speak must be John's, because John is the subject of that sentence.

If we mean that John also loves Peter's brother, then the sentence must be translated: *Johano amas Petron kaj lian fraton.*

It must also be carefully noted that *sia* can never qualify the subject:

Example: *Johano kaj lia amiko renkontis Petron*, John and his friend met Peter.

Here it will be observed that both "John" and "friend" are subjects of the verb; consequently, *lia* must be used. If the above English sentence, however, is slightly altered by saying, "John, walking with his friend, met Peter," then "friend" is no longer a subject, and the translation, therefore, is *Johano promenante kun sia amiko, renkontis Petron.*

In some complex sentences the *object* of a principal sentence becomes the *subject* of a subordinate sentence. This is exemplified by the following:

La patro vidis la sinjoron, kiu estis en sia gardeno, The father saw the gentleman, who was in his (the gentleman's) garden.

Here, "gentleman," the object of the principal sentence, becomes the subject of the subordinate sentence, and is represented by "who." Consequently, when *sia* is written, it must refer to "who," which, as stated, stands for "gentleman." If *lia* were substituted it could only refer to "father."

The simple rule to be remembered in cases such as the above is:

"Sia," being reflexive, can only refer to the subject of its own clause, and, for the same reason, can never be placed before the subject.

The following examples, with remarks thereon, should be carefully noted:

La domo de Anglo estas lia kastelo, An Englishman's house is his castle. *Lia* is used because "Anglo," which is referred to, is not subject.

Ŝi diris, ke la viro frapis ŝian hundon, She said that the man struck her dog. *Ŝian* is used because *viro* is the subject of the subordinate sentence.

La hundo amas sian mastron, The dog loves its master. *Sian* is used because it refers to the subject *hundo.*

La ĉevalo kaj ĝia mastro estis en la kampo, The horse and its master were in the field. *Ĝia* is used because *mastro* is also subject.

Mi vidis mian patrinon kun ŝiaj amikinoj, I saw my mother with her friends. *Ŝiaj* is used because *patrinon*, to which it relates, is not subject.

La knabinoj kaj iliaj fratoj iris kun siaj amikoj al {*sia* / *ilia*} *domo*, The girls and their brothers went, with their friends, to their {the girls' and their brothers' / the friends' brothers'} house.

Vocabulary

abi', fir
abel', bee
bapt', baptise
cirkonstanc', circumstance
diamant', diamond
hont', shame
kambi', bill of exchange
kompat', compassion, pity
konsider', consider
kontor', bureau, office
korb', basket
krem', cream
kurten,' curtain
kverk', oak
lepor', hare
lup', wolf
majes', majestic
marĉ', swamp, marsh
marŝ', march (v.i.)
membr', member
meti', trade, handicraft
minac', menace, threaten
mor', habit, usage
nest', nest
opini', opinion
pasament', lace
pir', pear
precip', particularly, especially
prem', press
prez', price
princ', prince
prov', attempt, try
punkt', point
puŝ', push
raŭk', hoarse
regiment, regiment
rekompenc', reward
renvers', upset
respond', reply
rev', day-dream, fancy
ripet', repeat
ros', dew
roz', rose
ŝat', like
ŝpruc', sprinkle
ŝtal', steel
ŝtel', steal
ŝuld', owe
zorg', care for
zum', hum

Exercise XIV.

1. He went into his office, and wrote his name on the bill of exchange. She repeated her story to the compassionate princess, who promised to look after her child. What is his trade? On that large oak there is a little nest, whose contents you would certainly like to steal. In my opinion, you should at once reply to the most important points in his letter. How much does his son owe to you? The regiment marched on to the swamp, and nearly all the soldiers perished. Does the new member like cream or milk in her tea? Very carelessly he upset the basket, which was full of pears. Who is there?

2. Kia bela pasamento! Ĉar vi kondutis hodiaŭ tre honte, vi ne havos la rekompencon kiun mi promesis al vi. La abelo zume flugas super la kampoj. La moroj de tiuj ĉi homoj estas tre hontaj. Kia estas via opinio pri mia provo? En frua mateno la roso kuŝas sur la folietoj de la rozoj. Li premis mian manon, diris malĝoje "adiaŭ!" kaj malaperis el mia vido por ĉiam. Post la kurtenoj, sin kaŝis la princo, kun ĉiuj siaj diamantoj. En tiuj cirkonstancoj, mi multe bedaŭras, ke mi ne povos aĉeti vian ŝtalon. Ili tiam komencis paroli tre laŭte kaj kolere; poste ili minacis kaj ekpuŝis min, kaj fine ili provis elĵeti min el la ĉambro. La leporo kuras tre rapide, precipe kiam lupo post iras. Kiel majesta estas tiu granda abio!

Key to Exercise XII.

A. Axe. Widow. Stranger. Blind woman. Isle. Little miss. Gun. Mad woman. In a motherly way. Sisterly. In the streets one often meets the deaf, the dumb and the blind who are beggars (*m.* and *f.*). I took my skates in order to skate on the ice. The little girl cried until she could not cry any more. With a needle one sews and with a comb one combs the hair. There are islands in both the north and south parts of this country, but I have not yet been to them. I am now a widow, as my husband has just died. He took the rifle, and shot in all directions like a madman. It is supposed that a pious person never sins even the least little bit. The joker again kissed the little children, and also the spinsters (single ladies). I am almost certain that you are but a deceiver.

B. Kvankam mi bone konas vian nomon kaj adreson, mi ankoraŭ ne intencas skribi al vi. Li estas honorulo, tre riĉa, sed ne tro feliĉa. Li prenis la pesilon kaj pesis la kupron. Ĝi pezis nur dek du funtojn. La orfino ridetis, kvazaŭ ŝi volas plaĉi al mi. La babilulo tuj denove ekparolis pri nenio; mi aŭskultis dum iom da tempo, kaj tiam ne volis aŭdi plu. Jen estas gladilo por gladi, kaj ŝlosilo por ŝlosi la pordon. La fosilo kaj la hakilo estas treege utilaj iloj.

Continued

SECTION I. ACCIDENCE

Irregular Nouns. The following are the most frequently used irregular nouns :

1. ἀνήρ (ὁ), man ; *voc.* ἄνερ, *acc.* ἄνδρα, *gen.* ἀνδρός, *dat. pl.* ἀνδράσι.
2. γάλα (τό), milk ; *gen.* γάλακτος, etc.
3. γόνυ (τό), knee ; *gen.* γόνατος, etc.
4. γυνή (ἡ), wife, woman ; *voc.* γύναι, *acc.* γυναῖκα, *gen.* γυναικός ; *dat. pl.* γυναιξί.
5. δόρυ (τό), spear ; δόρατος, δόρατι *or* δορί ; *pl.* δόρατα, δοράτων, δόρασι.
6. Ζεύς, Zeus, Jupiter ; *voc.* Ζεῦ, *acc.* Δία, *gen.* Διός, *dat.* Διί.
7. θρίξ (ἡ), hair ; *gen.* τριχός ; *dat. pl.* θριξί.
8. κύων (ὁ, ἡ), dog ; *gen.* κυνός ; *dat. pl.* κυσί.
9. μάρτυς (ὁ, ἡ), witness ; *gen.* μάρτυρος ; *dat. pl.* μάρτυσι.
10. οὖς (τό), ear ; ὠτός, ὠτί ; *pl.* ὦτα, ὤτων, ὠσί.
11. πῦρ (τό), fire ; πυρός, πυρί : *pl.* πυρά (watch-fires), πυρῶν, πυροῖς.
12. ὕδωρ (τό), water ; *gen.* ὕδατος ; *dat. pl.* ὕδασι.
13. υἱός (ὁ), son, is declined both regularly like λόγος, and as a noun of the third declension, υἱέος, υἱεῖ ; *pl.* υἱεῖς, υἱεῖς, υἱέων, υἱέσι.
14. χείρ (ἡ), hand ; *gen.* χειρός ; *dat. pl.* χερσί.

Comparison of Adjectives. I. The Usual Way, -τερος, -τατος. Most adjectives form the comparative by adding τερος, and the superlative by adding τατος to the stem :

Positive	*Comparative*	*Superlative*
δεινός, terrible	δεινότερος	δεινότατος
γλυκύς, sweet	γλυκύτερος	γλυκύτατος
μέλας, black	μελάντερος	μελάντατος
ἀληθής, true	ἀληθέστερος	ἀληθέστατος

Note 1. The comparative and superlative are declined regularly—*e.g.*, δεινότερος, -α, -ον ; δεινότατος, -η, -ον.

Note 2. Stems in ο with a short penult (that is, with the last syllable but one short) change ο into ω before -τερος and -τατος—as,

σοφός, wise σοφώτερος σοφώτατος

except when the penultimate (*i.e.*, last but one) vowel is followed by a mute and a liquid—as,

πικρός, bitter πικρότερος πικρότατος

Note 3. μέσος, middle ; ἴσος, equal ; πλησίος, near ; and ἥσυχος, quiet ; drop the ος and add αίτερος and αίτατος—as, ἴσος, ἰσαίτερος, ἰσαίτατος.

Note 4. Adjectives in ους (contracted for οος) form their comparison as follows : ἁπλοῦς, simple ; ἁπλούστερος (for ἁπλοέστερος), ἁπλούστατος.

Note 5. Adjectives in ων add έστερος and έστατος to the stem—as, εὐδαίμων, blessed ; εὐδαιμονέστερος, εὐδαιμονέστατος.

Note 6. Adjectives in εις form their comparison as though from a stem ending in ες—as, χαρίεις, graceful : χαριέστερος, χαριέστατος.

II. The Less Usual Way, -ιων, -ιστος. Some adjectives in υς and ρος form their comparison by changing the *termination* into ιων and ιστος—as,

αἰσχρός, base	αἰσχίων	αἴσχιστος
ἐχθρός, hostile	ἐχθίων	ἔχθιστος
ἡδύς, sweet	ἡδίων	ἥδιστος
ταχύς, swift	ταχίων / θάσσων	τάχιστος

Note. Comparatives in ιων are declined thus :

	Masc. & Fem.	*Neuter*
	Singular	
N., V.	ἡδίων	ἥδιον
A.	ἡδίονα or ἡδίω	ἥδιον
G.	ἡδίονος	ἡδίονος
D.	ἡδίονι	ἡδίονι
	Dual	
N., V., A.	ἡδίονε	ἡδίονε
G., D.	ἡδιόνοιν	ἡδιόνοιν
	Plural	
N., V.	ἡδίονες or ἡδίους	ἡδίονα or ἡδίω
A.	ἡδίονας or ἡδίους	ἡδίονα or ἡδίω
G.	ἡδιόνων	ἡδιόνων
D.	ἡδίοσι	ἡδίοσι

III. Irregular Comparison. The following adjectives are irregular :

ἀγαθός, good	ἀρείων, better	ἄριστος, best
	βελτίων ,,	βέλτιστος ,,
	κρείσσων ,,	κράτιστος ,,
	λῴων ,,	λῷστος ,,
	ἀμείνων ,,	—
ἀλγεινός, painful	ἀλγίων	ἄλγιστος
ἅρπαξ, robbing	ἁρπαγίστερος	ἁρπαγίστατος
γεραιός, old	γεραίτερος	γεραίτατος
κακός, bad	κακίων, worse	κάκιστος
	χείρων ,,	χείριστος
	ἥσσων ,, (*lit.* less)	(ἥκιστος)
καλός, beautiful	καλλίων	κάλλιστος
μάκαρ, happy	μακάρτερος	μακάρτατος
μακρός, long	μάσσων	μήκιστος
μέγας, great	μείζων	μέγιστος
μικρός, small	μικρότερος	μικρότατος
	ἐλάσσων, less	ἐλάχιστος
	μείων ,,	(μεῖστος)
	μειότερος	μειότατος
ὀλίγος, little, few	—	ὀλίγιστος
παλαιός, old	παλαίτερος	παλαίτατος
πένης, poor	πενέστερος	πενέστατος
πέπων, ripe	πεπαίτερος	πεπαίτατος
πολύς, much	πλείων / πλέων	πλεῖστος
ῥᾴδιος, easy	ῥᾴων	ῥᾷστος
φίλος, dear	φίλτερος	φίλτατος
	φιλαίτερος	φιλαίτατος
	φιλώτερος	φιλώτατος
ψευδής, false	—	ψευδίστατος

Note. Comparatives and superlatives are occasionally formed from nouns and pronouns—as, κλέπτης, thief : κλεπτίστερος, κλεπτίστατος ; κύων, dog ; κύντερος, more impudent, κύντατος ; αὐτός, self : αὐτότατος, his very self.

Adverbs. The regular adverbial ending in Greek is ως, and an adverb can be formed from an adjective by changing the ν of the genitive plural into ς—thus, σοφός, wise, (*gen. pl.* σοφῶν), adverb σοφῶς, wisely ; ψευδής, false, adverb ψευδῶς ; πᾶς, whole, (*gen. pl.* πάντων), adverb πάντως, wholly.

The neuter accusative of an adjective, singular or plural, is often used as an adverb—as, πολύ, much ; ῥᾴδιον, easily ; μέγα or μεγάλα, greatly.

The Comparison of Adverbs. The comparative of an adverb is the accusative

neuter *singular* of the comparative of the corresponding adjective, and the superlative of an adverb is the accusative neuter *plural* of the superlative of the corresponding adjective—as,

δεινῶς, terrible	δεινότερον	δεινότατα
ἀληθῶς, truly	ἀληθέστερον	ἀληθέστατα
αἰσχρῶς, basely	αἴσχιον	αἴσχιστα
χαριέντως, gracefully	χαριέστερον	χαριέστατα

NOTE. ἄνω, above, makes ἀνωτέρω, ἀνωτάτω; μάλα, much, very, makes μᾶλλον, μάλιστα. μᾶλλον is very common in Greek, and means *rather*; μάλιστα means *most of all, especially*.

Numerals

	CARDINAL	ORDINAL	ADVERBIAL
1.	εἷς, μία, ἕν, one	πρῶτος, first	ἅπαξ, once
2.	δύο, two	δεύτερος	δίς, twice
3.	τρεῖς, τρία	τρίτος	τρίς, thrice
4.	τέσσαρες, -α	τέταρτος	τετράκις
5.	πέντε	πέμπτος	πεντάκις
6.	ἕξ	ἕκτος	ἑξάκις
7.	ἑπτά	ἕβδομος	ἑπτάκις
8.	ὀκτώ	ὄγδοος	ὀκτάκις
9.	ἐννέα	ἔνατος	ἐνάκις
10.	δέκα	δέκατος	δεκάκις
11.	ἕνδεκα	ἑνδέκατος	ἑνδεκάκις
12.	δώδεκα	δωδέκατος	δωδεκάκις
13.	τρισκαίδεκα	τρισκαιδέκατος	—
14.	τεσσαρεσκαίδεκα	τεσσαρακαιδέκατος	—
15.	πεντεκαίδεκα	πεντεκαιδέκατος	—
16.	ἑκκαίδεκα	ἑκκαιδέκατος	—
17.	ἑπτακαίδεκα	ἑπτακαιδέκατος	—
18.	ὀκτωκαίδεκα	ὀκτωκαιδέκατος	—
19.	ἐννεακαίδεκα	ἐννεακαιδέκατος	—
20.	εἴκοσι	εἰκοστός	εἰκοσάκις
21.	εἷς καὶ εἴκοσι, or εἴκοσιν εἷς	πρῶτος καὶ εἰκοστός	—
25.	πέντε καὶ εἴκοσι, or εἴκοσι πέντε	πέμπτος καὶ εἰκοστός	—
30.	τριάκοντα	τριακοστός	τριακοντάκις
40.	τεσσαράκοντα	τεσσαρακοστός	τεσσαρακοντάκις
50.	πεντήκοντα	πεντηκοστός	πεντηκοντάκις
60.	ἑξήκοντα	ἑξηκοστός	ἑξηκοντάκις
70.	ἑβδομήκοντα	ἑβδομηκοστός	ἑβδομηκοντάκις
80.	ὀγδοήκοντα	ὀγδοηκοστός	ὀγδοηκοντάκις
90.	ἐνενήκοντα	ἐνενηκοστός	ἐνενηκοντάκις
100.	ἑκατόν	ἑκατοστός	ἑκατοντάκις
200.	διακόσιοι, -αι, -α	διακοσιοστός	διακοσιάκις
300.	τριακόσιοι, etc.	τριακοσιοστός	—
1,000.	χίλιοι	χιλιοστός	χιλιάκις
2,000.	δισχίλιοι	δισχιλιοστός	—
3,000.	τρισχίλιοι	τρισχιλιοστός	—
10,000.	μύριοι	μυριοστός	μυριάκις

NOTES. 1. The cardinal numbers from 5 to 100 (both inclusive) are indeclinable. Cardinals above 100 (such as 200, 300, etc.) and *all* the ordinals are declined like regular adjectives in ος.

2. The first four cardinals are thus declined:

	M.	F.	N.
N.	εἷς	μία	ἕν
A.	ἕνα	μίαν	ἕν
G.	ἑνός	μιᾶς	ἑνός
D.	ἑνί	μιᾷ	ἑνί

N., A.	δύο
G., D.	δυοῖν

	M. & F.	N.	M. & F.	N.
N.	τρεῖς	τρία	τέσσαρες	τέσσαρα
A.	τρεῖς	τρία	τέσσαρας	τέσσαρα
G.	τριῶν		τεσσάρων	
D.	τρισί		τέσσαρσι	

Like εἷς are declined its compounds οὐδείς and μηδείς, no one, none—as, μηδείς, μηδεμία, μηδέν, etc.

SECTION II. SYNTAX

RULE 1. Comparatives in Greek are followed by the *genitive* of the thing compared—as, ὁ ἥλιός ἐστι μείζων τῆς σελήνης, The sun is larger than the moon; πονηρία θᾶσσον θανάτου τρέχει, Wickedness runs faster than death. It would however be equally good Greek to translate *than* by ἤ, and then the noun following ἤ would be in the same case as the noun preceding—as, τὸ ἀληθὲς ἀεὶ μεῖζόν ἐστιν ἢ τὸ ψευδές, Truth is always greater than falsehood; φιλῶ τοῦτον τὸν παῖδα μᾶλλον ἢ ἐκείνην τὴν κόρην, I love this boy more than that girl.

RULE 2. The comparative and superlative may refer sometimes to a single subject—as, γελοιότερόν ἐστιν εἰπεῖν, it is somewhat ridiculous to say; καλλίστη γυνή, a very beautiful woman.

SECTION III. TRANSLATION.

VOCABULARY

δεινός, ή, όν, terrible
φίλιος, α, ον, friendly
ἔχω, I have
ἡ ἀρχή, beginning
πρός, near, with (governs accusative)
μακάριος, α, ον, blessed, happy
πτωχός, cringing, poor
το πνεῦμα, ατος, breath spirit (cf. pneumatic)
ὅτι, because (ὅτι also = *that*, conjunction).
ἡ βασιλεία, kingdom
ὁ οὐρανός, heaven (cf. Uranus)
σώζω, I save (future σώσω)

Translate into English: 1. ὁ θανατός ἐστι δεινὸς τοῖς κακοῖς. 2. οἱ δίκαιοι ἦσαν φίλιοι τοῖς πένησιν. 3. οἱ Ἕλληνες οὐκ ἔχουσι σόφους ἡγεμόνας. 4. ἐν ἀρχῇ ἦν ὁ λόγος, καὶ ὁ λόγος ἦν πρὸς τὸν Θεόν, καὶ Θεὸς ἦν ὁ λόγος. 5. ὁ Ξενοφῶν ἦν στρατηγὸς τῶν Ἑλλήνων. 6. μακάριοι (εἰσι) οἱ πτωχοὶ τῷ πνεύματι· ὅτι αὐτῶν (= of them—*i.e.*, theirs) ἐστιν ἡ βασιλεία τῶν οὐρανῶν. 7. οἱ ποιμένες θαυμάζουσι τὴν χιόνα ἐν τῷ χειμῶνι. 8. σώσομεν τὴν πατρίδα ἐκ πολέμου. 9. εἰσὶν ὀλίγοι ποταμοὶ ἐν τῇ Ἑλλάδι. 10. ὦ Πέρσα, ἔχεις τὰ τοῦ ἀγγέλου ὀστᾶ ἐν τῷ κανῷ. (Note the order of the words: τὰ agrees with ὀστᾶ, and τοῦ with ἀγγέλου; but Greek says "the of the messenger bones," not "the bones of the messenger.")

Note that Greek uses the article with abstract nouns—*e.g.*, ὁ θάνατος, death, in sentence No. 1 above; also frequently with proper names—as, ὁ Ξενοφῶν, Xenophon, in sentence No. 5.

KEY TO EXERCISE VI.

1. οἱ βάτραχοί ποτε πρέσβεις ἔπεμψαν ἐπὶ τὸν Δία καὶ ᾔτησαν βασιλέα αὐτοῖς παρασχεῖν. 2. ὁ Ζεὺς ξύλον εἰς τὴν λίμνην ἔρριψεν. 3. οἱ βάτραχοι φόβῳ ἑαυτοὺς εἰς τὰ τῆς λίμνης βάθη ἔρριπτον. 4. ἀλλ' ὡς ἀκίνητον ἦν τὸ ξύλον, ταχέως αὐτοῦ κατεφρόνουν καὶ ἐνόμιζον τοῦτον τὸν βασιλέα ἀνάξιον εἶναι. 5. ᾔτησαν τὸν Δία ἄλλον βασιλέα. 6. ἔλεγε "ὑμεῖς ἔστε μωροί," καὶ ὕδραν (literally: *a hydra*) αὐτοῖς ἔπεμψεν ὑφ' ἧς κατησθίοντο.

Continued

NOTE. The next instalment of the SPANISH course appears in Part 42 of the SELF-EDUCATOR.

THE WONDERFUL RANGE OF COLOURS DERIVED FROM COAL-TAR

Displayed graphically according to groups. [For explanation see Dyeing.]

NATURE & USES OF COAL-TAR DYES

How Artificial Dyes are Manufactured. Their Nomenclature, Classification and Industrial Uses

Continued from page 5908

By HERBERT ROBSON

COAL-TAR is a very complex body, containing a great number of hydrocarbons, phenols, bases, etc. This is the great source of the artificial colouring matters, although petroleum residues are also used to a less extent. The tar is first submitted to fractional distillation, the fractions being as follow:

First runnings	..to 110° C.
Light oils	110° C. to 210° C.
Carbolic oils ..	210° C. to 240° C.
Creosote oils ..	240° C. to 270° C.
Anthracene oils ..	270° C. to 400° C.

The bodies passing over from the retort to the receiver between the indicated temperatures are kept separate, and by further and more minute fractional distillation and working up the raw products of coal-tar, colour materials are obtained. These are benzene, toluene, xylene, naphthalene, anthracene, phenol and cresol.

From these are obtained the "intermediate products." These are: nitro compounds, as, for instance, nitrobenzene; sulphonic acids of hydrocarbons; primary amines and their sulphonic acids; phenols, etc. For instance, nitrobenzene is prepared by the action of nitric acid on benzene, and aniline is prepared from this by reduction with iron and hydrochloric acid.

Synthetic Dyes. As it is impossible to devote sufficient space to give more than a vague idea of the methods of the colour manufacture we will take one or two examples of synthetic dyes and show the manner in which they are built up.

Aniline, in the early days of the industry, was never obtained free from an admixture of toluidine, and the famous colour magenta or fuchsine was obtained from this intermediate product by oxidation with arsenic acid.

The way in which artificial alizarin was discovered furnishes a good example. A body to which formula $C_{14}H_{10}O_4$ was assigned was found to exist in madder and to this the name alizarin was given. Later a hydrocarbon with the formula $C_{14}H_{10}$ was obtained from this, which proved to be identical with anthracene. The attempt, therefore, was made to oxidise anthracene, with a view to obtain artificial alizarin and by treating it with chromic acid, anthraquinone ($C_{14}H_8O_3$) was obtained. This was acted upon by bromine, and the product, on fusion with caustic potash, yielded potassium bromide and alizarin. This was too expensive a method and the process was quickly simplified. It is given here simply as a mode of working.

Many artificial dyestuffs are prepared by combining aniline or its derivatives with various bodies. For instance, Wool Yellow is made in this way with aniline and fustic, Alizarine Yellow by combining paranitraniline and salicylic acid. The nitro colours are made by treating the long series of intermediate products with nitric acid; for instance, picric acid is prepared by the action of nitric acid upon phenol and Aurantia by the action of nitric acid upon diphenylamine.

Cachou de Laval, the first sulphur dye, was made by fusing sawdust with sodium sulphide, but it was not until the sulphur colours came into the category of coal-tar dyes that they found favour with the dyer. Vidal prepared Vidal Black in 1893 by fusing para-amido-phenol with sulphur and sodium sulphide at about 200° C. He was the first, also, to recognise the importance of the presence of nitrogen in the coal-tar derivative used for "melt," as it is called. He found that the diphenylamine and its derivatives gave sulphur dyes at lower temperatures than the amidophenol—namely, at temperatures varying from 150° C. to 180° C. Among the results of this discovery we may mention Immedial Black, which is prepared by fusing paraoxy-ortho-para-di-nitro-di-phenyl-amine with sulphur and sodium sulphide. Thiocatchines are made from the diamines. Clayton Black is prepared by treating nitrosophenol with acid solutions of thiosulphates. The Kryogenes are prepared from dinitronaphthalene. An enormous amount of work has been done in this direction and is still proceeding, and the methods of manufacture are both numerous and complicated. They are at present entirely empirical, as hardly anything is known either of the composition of the sulphur dyes or of the chemical reactions concerned in their formation. The general principles on which their preparation depends will, nevertheless, be easily gathered from a perusal of this paragraph. When we consider the enormous number of the coal-tar derivatives and the fact that practically all of them which have been tested have given some result, whether valuable or the reverse, on fusion with sodium sulphide, we can easily appreciate the difficulties of the investigation.

Dictionaries of artificial dyes, such as those of Hurst, of Green, and of Rawson, Gardner and Laycock, give the chemical and commercial name, and as far as possible the method of preparation of each dyestuff.

Nomenclature of Dyestuffs. An aniline was the first coal-tar dye discovered, and since the days of Perkin's Mauve the British public have spoken of all artificial dyes as anilines. The alizarines, however, are not anilines, and the discovery of this large group was very early in the history of coal-tar dyes. The first sulphur colour was not even a coal-tar dye, and petroleum residues are used in some places (Russia, for instance) in place of coal-tar as a raw material. The correct term, therefore, unless we are speaking specifically of an aniline, is "artificial organic colouring matter," which completely fills the field.

Artificial dyes, to content ourselves with a shorter term, are definite chemical substances, but the makers for good and sufficient reason put them on the market under a commercial or "trivial" name. It is obvious that it is easier for the dyer to ask for Bismarck Brown than for hydrochloride of benzene-diazo-phenylene-diamine, and this is simplicity itself as compared with the chemical names of some of the dyestuffs. The only inconvenience is that the same dyestuff is often on the market under a variety of names. That already instanced was called Bismarck Brown for obvious complimentary

reasons by its German discoverer, Manchester Brown by the Manchester firm who improved the method of manufacture, English Brown possibly by way of protest, Phenylene Brown from its composition, Leather Brown when it was found to be very suitable for that material, and Cinnamon Brown because of the rich reddish-brown shade it gives.

As a rule the commercial name suggests the colour produced by the dyestuff (Diamond Yellow), and in some cases the particular tone or tint (Turquoise Blue). It frequently gives an indication of the chemical origin of the dyestuff (Resorcin Brown), or claims special properties of resistance (Milling Yellow), or, as in the case of Night Blue, of remaining unchanged in an artificial light. Very frequently the recommended use is indicated—as, for instance, Wool Scarlet, Union Black, Cotton Blue; or the way in which it is to be used—as, for instance, Chrome Green, Spirit Blue.

Names Indicating Colour. The names indicating colour have been taken from all sources. From flowers we get Primuline, Rhodamine and Rosophenin, from the Greek and Latin respectively for a rose, Mimosa, and others. A number of dyes commence with a Greek or Latin name meaning or suggesting a colour: Chrysamine, Chrysoidine, Auramine (golden), Citronine (lemon), Cyanol, Cyanine (blue), Eosine, Eosamine (*eos*, the blush of dawn), Flavine (yellow), Irisamine (*iris*, the rainbow), Nigrosine (black), Pyramine (fiery), Chlorine (yellow), and others. Uranine comes from uranium, whose compounds show fluorescence, now said to be due to radium, and Fluorescent Blue and Fluoresceine convey the same idea of a changing colour effect. Some names are frankly popular and topical—as, for instance, Magdala Red, Congo Red, Guinea Green; and others, as in the case of Perkin's Mauve and Meldola Blue commemorate the discoverer.

The letters following the names are not meaningless; as a rule they indicate the particular tint, thus Brilliant Congo R gives a frank red, while Brilliant Congo G (*gelb*, German, yellow) has a yellowish tinge. The degree is shown, as in the case of the Benzopurpurines, which are sent out in four "brands" ranging from B, a slightly bluish red, through 4B and 6B to 10B, a very bluish red.

Bancroft first called the direct natural dyestuffs "substantive," and those requiring a mordant "adjective" colours, and the names are applied in the same connection to the artificial dyes.

Classification. Classification is essential in the consideration of any subject, but with the artificial dyes, as with all other great groups, the sub-classification is difficult, and, on whatever principle we proceed, is only a makeshift at the best, though a necessary one. In classifying the artificial dyes we may consider their chemical composition, their method of application, or their effects upon different textiles. It seems best to arrange them with some reference to all these points, and we propose to make six main classes as follow:

(*a*) Direct Cotton Colours; (*b*) Acid Colours; (*c*) Basic Colours; (*d*) Ordinary Mordant Colours; (*e*) Acid Mordant Colours; (*f*) Insoluble Colours.

It must, however, be noted that there are dyes which belong to two or even three of these classes.

Direct Cotton Dyes. These dyes are so called because they dye vegetable fibre without the assistance of a mordant. It is evident, therefore, that they dye all other textiles in the same way, for cotton has less affinity for dyestuffs than any other fibre in use for the manufacture of textile fabrics. With the exclusion of the sulphur dyes—which are not classed as direct dyes, since they need a special bath, and in this course it seems best to take with the insoluble dyes—the first direct cotton dye discovered was Congo (Congo Red), in 1884, by Bottiger.

All the direct cotton dyes are soluble in water. They are compounds of various colour-acids with alkalis, and are, therefore, all decomposed by acids. Unless, then, the colour-acid set free happens to have the same colour as the original dye, the shade produced is not fast to acids. Most of the group are decomposed by hard water with precipitation of a lake and, therefore, the water for the dyebath should be softened for use. The direct cotton dyes used directly are not very fast, as a rule, especially on cotton and linen, but their resistance to external agencies can be greatly increased by treating the goods in various ways after dyeing. Sulphate of copper and chromium compounds are largely used for this purpose, and a few of the direct cotton dyes (for instance, Primuline) can be fixed by diazotising.

The direct cotton colours are not much in vogue for wool, which can be more cheaply coloured by means of acid dyes, but for mixtures of wool and cotton the direct dyes are used in a neutral bath.

Accelerating and Retarding Agents. Every member of the class requires an assistant in the dyebath, either to accelerate or to retard the going on of the dye. For the former purpose Glauber's salt or common salt is employed; for the latter, carbonate of soda, or even caustic soda or soap. It is very common to use both a retardant and an accelerant. Thus, in many cases the first part of the dyeing is done in the presence of carbonate of soda, and Glauber's salt is added to the bath later. Soap is often used with Glauber's or common salt for mode shades.

The direct cotton colours are dyed on wool at the boiling point, and in a neutral or alkaline bath, and with the same assistants as cotton. The Benzopurpurines, and some others can be dyed in a bath made slightly acid with acetic acid, but even with these a neutral bath is preferable. For mixtures of wool and cotton, 2 per cent. of potash, and 10 per cent. of phosphate of soda make the best dyebath. The use of acids tends to make wool take a redder shade than cotton does under the same circumstances, and this prevents level dyeing of mixtures.

In the case of silk, the dyebath is best made with soap broken with 4 per cent, of acetic acid. Enter the goods at about 130° F., bring to the boil, and boil 45 minutes, or to shade. An after treatment exactly as for cotton is required if great fastness is a desideratum, although the direct cotton colours are faster on either wool or silk than they are on cotton.

The direct cotton colours can be combined ad libitum in the same bath so that any possible variety of shade is easily procured. Whenever practicable, however, those dyes should be selected for mixing which require the same assistant. If this cannot be done the assistant must be chosen with regard to the dye which is added in largest quantity.

Baths of the direct cotton dyes very rarely exhaust, and can be kept standing, reinforcing them with more dye and Glauber's salt, etc., when each fresh batch of goods is put in. The shorter the bath—that is, the smaller the excess of weight of the dyebath over that of the goods—the better the exhaustion. Large amounts of assistants also favour exhaustion, which, of course, depends besides on the affinity of the fabric for the dye, so that, other things being

equal, the bath will exhaust better with wool or silk than with cotton. A strong bath has the advantage, in the use of the direct cotton dyes, that it gives deeper and fuller shades. Hence it should not be diluted by heating it with direct steam. The heat should be applied with a closed coil or by means of a steam jacket. It is a good plan to allow the goods to cool for some time before lifting them. This conduces to uniformity of shade, which is to some extent imperilled by the use of strong and short baths. A fair average length of bath is from 200 to 250 gallons per 100 lb. of goods.

One of the most important properties of the direct cotton colours is that they act as mordants to the basic dyes so that very fast colours can be got by topping—that is, by dyeing first in a bath with direct dyes and then redyeing with a basic colour. The lakes formed, however, are decomposed at about 160° F., so that the topping bath must be below that temperature.

The direct cotton colours are very numerous, and only a few examples can be quoted. They include the Benzo colours, Leonhardt's Mikado colours, many of Cassella's Diamines, Chrysamine, the Titan colours of Read Holliday & Sons, the Zambesi dyes of the Berlin Aniline Co., and many others. A large number of these indicate their property of dyeing unmordanted cotton in their names—for instance Direct Grey, Direct Yellow, Direct Red, and so on.

The Dyebath. The proportion of dye and assistants required varies greatly, but the best proportions are given for each dye in the recipes furnished by the makers. Some, such as Benzoazurines, Azo Blue, etc., have to be dyed at the boil, while others, such as Chrysamine and Brilliant Yellow, must not be boiled. The diamines brought out by Cassella in 1889 belong partly to this class. Some are diazotisable colours. Certain diamines have the peculiarity that they are not fixable by metallic salts. Thus Diamine Blue CB has to be diazotised, and developed with beta-naphthol. In dyeing with Chrysamine, one of the fastest of the coal-tar dyes, no copper must be present in any form or the yellow colour will be spoiled. There is little difference between cotton and wool as regards the direct cotton dyes. The chief point is that after treatment is not so frequently required in the case of wool as it is with cotton on account of the greater affinity for dyes in general possessed by the former fibre.

As regards the after treatment, bichromate of potash or sulphate of copper, already alluded to in this connection, are the usual agents, but diazotising is often resorted to. In this process the goods, after dyeing and rinsing, pass through a bath containing 1½ per cent. to 2½ per cent. of sodium nitrite and 5 per cent. to 8 per cent. of hydrochloric acid. This bath must be kept cold, using ice if necessary. Development follows with one of the numerous developers upon the market. Beta-naphthol (1 per cent. dissolved in caustic soda) is perhaps the most commonly used developer. This diazotising process affords great scope for shading, and dyeing to pattern, for mixtures of azotisable and non-azotisable dyes, and a mixture of developers can be used on the principle that the final colour depends partly upon the developer. Care must be taken, however, not to use together a developer requiring an acid liquid and one needing the presence of free alkali. Resorcin, for example, which is used to fix Primuline and Diamine Black, like beta-naphthol, has to be dissolved in caustic soda, whereas some developers require acid.

Basic Dyes. These are the oldest coal-tar dyes known, inasmuch as Perkin's Mauve is one of them. Safranine was discovered in 1863, and Bismarck Brown—the first azo dye—in 1864. In constitution the basic dyes consist of salts of colour bases. They are direct dyes for woollen and silk, and adjective dyes for cotton. Most of them are soluble in water, and all in spirit. A few of them, such as Auramine, are decomposed by hot water, and they should not be used with hard water, which precipitates, and wastes them, as it does the direct cotton colours. They are not remarkably fast. On cotton they are usually dyed on a tannin and tartar emetic mordant. Iron-salts are sometimes substituted for the antimony salt, or Turkey red oil or soap mxed with acetate of alumina. If the tannin process is adopted a very short tannin bath at about 170° F., and containing about 5 per cent. of tannin is used, although some, such as Fast Cotton Blue, require more tannin for several hours (six at least). The goods then pass direct into a solution of from ½ per cent. to 2½ per cent. of tartar emetic according to shade. This bath is kept standing, and is reinforced as may be necessary. If difficulty is found in getting level shades, as occasionally happens, the goods should be mordanted after instead of before dyeing. In dyeing dark shades it is a good plan to use decoctions of natural tannins, such as sumach or galls, as the natural colouring matter present in the solution saves some of the artificial dye. Yet another method of mordanting is to dye first with a direct cotton colour of the same shade. In a few cases (as Victoria Blue) the colour is so stable that the fibre cannot act upon it with the assistance of acid.

On wool, the basic colours are now of comparatively small importance as the acid dyes have supplanted them to a large extent. The basic dyes are always dyed on wool in a neutral bath. Acetic acid is put in if the water is hard, but merely in sufficient quantity to soften the water and prevent the lime in it from throwing down the colour base, whereby the shade would be made unlevel and spotty. Too much acetic acid retards the exhaustion of the bath. Glauber's salt is sometimes used. Silk is dyed in a neutral bath, as a rule, but it may be slightly alkaline or acid without disadvantage. As is usual in silk dyeing, a soap bath is commonly employed. The goods are entered lukewarm, and the bath is gradually heated to about 200° F., at which temperature the dyeing is finished. The basic dyes are faster on silk than on cotton or wool.

Among the chief basic dyes may be mentioned Safranine, Auramine, Cassella's Thioflavine, Nile Blue (B.A. and S.F.), Turquoise Blue (Bayer), Phosphine (Brook, Simpson & Spiller), the Hoechst Indamines, the Indulines, and others. The Hoechst Janus dyes belong to this group. They were introduced in 1897, and are azo dyes which are remarkable for dyeing cotton, wool and silk direct from acid baths. A typical recipe for these dyes is 1 per cent. to 3 per cent. of dye, 2 per cent. of sulphuric acid, and 5 per cent. to 20 per cent. of Glauber's salt.

Acid Dyes. These are salts, and the colour has to be liberated by the addition of acid to the bath. In the case of wool the fibre may be soured before entering the bath. An average recipe for wool is: dye-stuff, ½ per cent. to 6 per cent.; Glauber's salt, 10 per cent., sulphuric acid, 4 per cent. Enter hot, raise to the boil, and boil from an hour to an hour and a half. Their first representatives were Fluoresceine, and its bromine-derivative, Eosine, both discovered in

1874. When first put on the market by Bayer and Caro, Eosine was sold at £18 per pound. The Acid Rhodamines were discovered by Ceresole in 1888. The acid dyes are mostly soluble in hot water. They can be dyed on cotton with the ordinary mordants, but they are not much used. From ½ per cent. to 4 per cent. of dye is required. The acid dyes have less tinctorial power than the basic dyes. The average amount of dye needed may be put at 3 per cent.

On silk, the acid colours are used exactly like the basic, except that the baths are usually made more acid and that lower temperatures (say, 140° F.) are employed to check any tendency to want of uniformity. Silk has little affinity for the acid dyes. It is as substantive dyes for wool that the acid dyes find their chief application. The wool scarlets of Read Holliday & Sons, Brilliant Croceine (Cassella), Rose Bengal, Tartrazine (S. C. I. Basle), the Fast Yellows, Alkali Blue (Brook, Simpson, & Spiller), Wool Blue (Bayer), and last, but not least, the excellent blacks of this group, such as Naphthalene Black (Read Holliday), Naphthol Black and Naphthylamine Black (Cassella), Victoria Black (Bayer), form a brief list of some of the most important acid dyes.

Some of the dyes, such as the Chromotropes, Chrome Brown, Alizarine Yellow, etc., are fixed with chromium fluoride, alum, or bichromate, added either at the end of the dyeing to the dyebath itself, or applied to the dyed fabric in a separate vat. A few acid dyes, such as Eosine and Phloxine, require the use of acetic instead of sulphuric acid, or the resulting shades are wanting in brightness.

Mordant Colours. This group is divided into two classes—the ordinary mordant dyes and the acid mordant dyes. The latter behave as acid dyes after heating with a metallic salt or oxidation with bichromate of potash and sulphuric acid, with or without the addition of Glauber's salt. The ordinary mordant dyes are substances which have the power of combining with the oxides of various metals, forming insoluble lakes, and the use of these dyes depends upon the formation of the lake upon the fibre.

The general method of the application of the acid mordant dyes is to mordant and then dye the material with them at the boil with sulphuric acid and Glauber's salt, and when the bath is exhausted to allow it to cool to about 150° F., when the bichromate is added, the goods being lifted the while. The dyeing is then resumed and continued for about half an hour longer. If more than one dye is in use, those should be chosen which require the same mordant. Among the most important of these dyes are alizarine and the alizarine colours, the Anthracene and Anthracite Blacks, Crumpsall Yellow (Levinstein), Alizarine Azo Yellow (Read Holliday & Sons), Chrome Patent Green (Kalle), and Gallanil Violet (Durand Huguenin & Co.).

Mordant Processes. With the ordinary mordant colours the processes may be classed as two-bath and one-bath. In the former the dye and the mordant are used in separate baths, sometimes the dyeing preceding the mordanting and sometimes the reverse. In the one-bath process the mordant and the dye are used in the same bath. The chief mordants used are various salts of iron, aluminium, and chromium.

One of the most important branches of this kind of dyeing is alizarine dyeing. To get alizarine Turkey red on cotton various methods are employed. The goods are first impregnated with oleine or, better, with Turkey red oil, dried and steamed. They are then dyed with from 5 per cent. to 20 per cent. of dye and a little acetic acid if the water is hard. They are entered cold, and the bath is very slowly heated to nearly boiling and kept at that temperature until exhausted. The goods are wrung, rinsed, and dried, and mordanted in a fresh bath, the mordant being selected according to the colour wanted. If the mordanting is to precede the dyeing, the metal must be fixed on the fibre by a bath intercalated between the mordanting and the dyeing baths. One method is, after treatment with Turkey red oil, to wring the goods, and then dry them at a moderate heat (about 130° F.). They are then given several hours in a bath of basic sulphate of alumina made by dissolving alum in hot water and adding crystals of carbonate of soda when cold. Add 1 lb. of the crystals for every 4 lb. of alum; then fix the alumina in a bath of chalk or phosphate of soda and dye. In this process the dyebath must contain lime.

Erban and Specht were the first to dissolve the dye in a solution of ammonia, fixing with alumina, and this was found to be a useful process. For dark shades aluminic acetate is used and converted into the basic insoluble form by subsequent steaming. For light shades aluminate of soda is used. In this case the steam has to be accompanied by acetic acid to form the basic acetate. Linen is treated as cotton.

Mordant Colours on Wool. For wool with the mordant colours a common mordanting bath is bichromate of potash, to which a reducing acid, such as lactic, formic, or acetic, has been added. The chromium is deposited on the fibre as sesquioxide, and at once forms the lake when the goods pass in the dyebath. About 3 per cent. of bichromate is used for dark shades, less for lighter ones. The amount of acid is rather less. With chromium fluoride, use 2 per cent. to 4 per cent., and 1 per cent. to 2 per cent. of oxalic acid. When alumina is used, the bath is made with 5 per cent. to 8 per cent. of sulphate of alumina, or 6 per cent. to 10 per cent. of alum and 3 per cent. to 8 per cent. of tartar. This bath should be rather long (say, forty times the weight of the wool). If there is too much alumina present, the wool absorbs acid as well as alumina, and the shades on dyeing will be deficient in colour and fastness. If there is too little alumina the colours will be loose to rubbing. The baths must be absolutely free from iron or copper. Iron is a common impurity of alumina salts. Work the wool in the bath—cold—for about 15 minutes. Then boil up and boil about one hour, or rather less. Then dye. When iron is used, the bath is made with 3 per cent. to 5 per cent. of ferrous sulphate, and 2 per cent. to 3 per cent. of tartar, or 1 per cent. to 1½ per cent. oxalic acid.

In dyeing wool, with some colours, for instance, Alizarine WS, the process is different. A bath is made with 10 per cent. of Glauber's salt and the dye. After the wool has been boiled in this for half an hour it is lifted and 4 per cent. of sulphuric acid is added to the bath. The wool is re-entered and boiled for another half-hour. Then the iron, chrome, or alumina mordant is added, and after 45 minutes' more boiling the process is finished.

Mordant colours are too expensive for silk, as a rule, but when used, alumina is the chief mordant, as silk is difficult to mordant with chromium.

Besides alizarines, this class includes some of the anthracenes, such as Anthracene Brown, Flavopurpurine, Chrome Fast Yellow (Berlin), Galloflavine (B.A. & S.F.), Diamond Blacks, Gallamine Blue (Bayer), Chromocyanine (Durand Huguenin).

Continued

THE MANAGEMENT OF BEES

The Principles of Apiculture. How to Obtain a Good Return of Honey. The Profits of Bee-keeping. Expert's Certificate. Diseases of Bees

By J. B. LAMB

APICULTURE, or bee-keeping, as it is popularly called, is the practical and scientific management of bees. If a stock of bees be placed in a garden in a suitable district, it may be depended upon to make provision for the winter, though it is almost certain to throw off a swarm; but with management an expert bee-keeper may prevent swarming, and, if the weather proves favourable, at least 20 lb. of surplus honey may be reasonably expected from the stock.

The object of this article is to give practical information on elementary and advanced bee-keeping, with the view of enabling persons who reside in suitable districts to avail themselves of the opportunity of increasing their income in a way which will give both pleasure and health.

Inhabitants of the Hive. In the summer months there will be found in every stock of bees one queen, some hundreds of drones, and many thousands of worker bees. The queen is the only perfect female, her sole duty being to lay eggs to maintain, and, in the swarming season, to increase, the size of the colony. Drones are the male bees, and are brought into existence to provide for the fertilisation of the young queens. Worker bees are undeveloped females, and upon them devolve the duties of gathering honey and pollen, secreting wax for comb-building, feeding the larvæ, keeping the hive clean and ventilated, and protecting it from robber bees. As will be seen on reference to the illustrations, the queen bee [2] has a long, tapering body, with somewhat short wings; the drone [3] is the largest of the three; and the worker bee [1] is the smallest. The queen does not sting unless she finds a rival in the hive, hence she can be taken in the hand freely; the drone does not possess a sting, and never works, but helps to maintain the heat of the hive; the worker has a sting, and uses it freely if provoked, but, with a few exceptions, does not sting unless in some way molested.

1. THE WORKER BEE

The three races of bees most popular in Great Britain are English, Italian, and Carniolan, the first-mentioned owing to their numerous good qualities are most generally kept. Italians are exceedingly pretty bees, the queens are very prolific, and without doubt the native race has been much improved by crossing with the Italian. Carniolan bees are the most gentle of all, but their great fault is excessive swarming.

2. QUEEN BEE

The Swarm and the Stock. The difference between a swarm of bees and an established stock is not generally known. When a hive is very crowded with bees and brood, which is usually in the early part of June, the natural instinct of the bees prompts them to make arrangements for the queen and most of the flying bees to leave the hive for a new home. These bees, which may number from 10,000 to 25,000, according to the size of the hive, constitute a swarm. When combs have been built in a hive, and the queen has been laying for some time, then the bees with the combs containing eggs, larvæ, honey, and pollen constitute a stock. It will be remembered, therefore, that in buying a swarm only bees will be sent by the seller; but when a stock is purchased, the bees will be sent on combs containing brood and stores.

In purchasing swarms a certain weight of bees ought always to be stipulated for, since 2 lb. and 5 lb. of bees are both legally "swarms." The price charged is about 2s. 6d. per lb., and the larger the swarm the better will be the return of honey. A swarm of 5 lb. is a good one, but it must be borne in mind that bees lose weight in transit, hence allowance must be made for this should the weight be tested.

The Comb. There are two kinds of comb foundation, "brood" and "drone." When brood-foundation is converted into comb, worker bees can be raised in the cells, and when drone-foundation is built out the cells are of the size required for breeding drones. These foundations are made in various thicknesses, and in different sizes. A very serviceable foundation for brood-raising is that known as "Weed," running seven or eight sheets to the pound; for shallow frames drone-foundation should be used; and for sections the "extra thin super" is the best and cheapest in the long run.

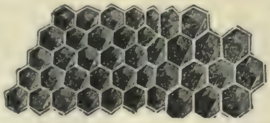
Honeycomb consists of six-sided cells [4], in which bees are raised and honey and pollen stored. Drones are hatched from cells, four of which measure an inch; worker bees are raised in smaller cells, five of which make an inch, whilst the larvæ of queens are provided with enlarged cells [5], which, when finished, are shaped somewhat like an acorn, hanging downwards in the hive.

The Eggs and Comb-frames. The queen can lay both fertile eggs and those which are called unfertile. The first in the ordinary course produce worker bees, yet if the larvæ, when just hatched, are fed on a highly nutritious food until the cell is sealed over, they develop into queen bees. This accounts for the statement that worker bees are undeveloped females. The eggs which are technically known as "unfertile" always produce drones; hence, if a queen should fail to be fertilised, she can lay only drone eggs. In all these cases—that is to say, with the queen, the worker, and the drone—the grub hatches out of the egg at the end of three days, and the cell is sealed over about the ninth day. The larvæ are fed by "nurse-bees," which is the name given to workers before they leave the hive to gather honey and transfer pollen.

3. DRONE BEE

A hive is the house provided for the stock of bees and comb-frames. In olden times bees were

kept in straw hives called skeps, and when the honey was wanted the bees were suffocated by means of sulphur fumes. This cruel way of obtaining the honey is fast dying out, and the humane method of taking the honey in sections, and by extracting it from frames, is becoming more and more popular every year. The British Bee-keepers' Association has fixed upon a "standard" frame [6] to contain the honey-comb in the body-box of the hive, the outside measurements of which are 14 in. long at the bottom, 8½ in. deep, and the top bar is 17 in. long, so that in almost all apiaries the internal dimensions of hives are the same, the only variation being in the number of frames.

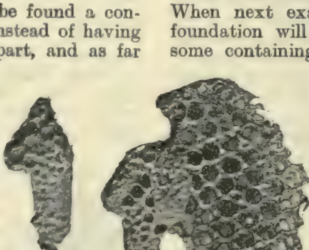


4. SPECIMENS OF COMB
Worker on the left,
Drone on the right

Hives and Accessories. There are many different hives on the market, but one of the most serviceable of all is that known as the "W. B. C." [8]. A useful hive for tiering up for run honey is Meadows' "XL All." If readers have the opportunity of purchasing second-hand ones, which can usually be bought at a material reduction in price, hives by any of the following makers, amongst others, may be safely purchased: Lee, Blow (now Taylor), Abbott, Meadows, and Neighbour, those by the last-mentioned being now sold by Abbott. But an assurance should in all cases be obtained from the seller that diseased bees have not been kept in them. Even with this guarantee, the hives ought to be thoroughly cleansed by being well scrubbed with hot soapy water, and, when dried, painted with a solution of one part of Calvert's No. 5 carbolic acid to two parts of water. After being exposed to the air the smell will disappear, and the hives will be ready for occupation.

When a hive is purchased new, the following accessories must be obtained with it: one dozen standard frames fitted with full sheets of brood-foundation wired; W. B. C. ends for each frame; a division board; a square of coarse calico, some quilts, a smoker, a veil, a feeding bottle, and a rack of sections containing full sheets of foundation. These will cost from 25s. to 35s., according to the quality of the hive.

In arranging an apiary it will be found a convenience to work hives in pairs, instead of having them spaced varying distances apart, and as far as possible the roofs, lifts, and floorboards should be interchangeable. As hives are best examined from the rear, or from the right-hand side, care must be taken that stocks in the rear are not so near as to cause the operator to be within the line of flight of the bees. Advantage should be taken of the shade which is provided by large trees, for in the summer time the glaring sun upon the hives is a frequent cause of swarming.



5. QUEEN CELLS

Hiving the Swarm. When the swarm arrives, prepare the hive for its reception by taking off the roof and quilts, and removing the division board with some of the frames of foundation, leaving in half a dozen spread out an equal distance apart. Put on the top of the frames the sheet of calico, making a hole 2 in. in diameter in the centre; then place over it the feeding bottle containing syrup made of 6 lb. of loaf sugar (preferably Tate's No. 1), 4½ pints of water, 5 teaspoonfuls of vinegar, and a heaped teaspoonful of salt, boiled in an enamelled saucepan for three minutes, care being taken that the syrup does not burn. On the top of all put the woollen wraps, then replace the lid of the hive. Prop up the body-box in front an inch; then, from the alighting board of the hive to the ground put a board 2 ft. wide, for the bees to run up into the hive, since bees always crawl up, never down. Prepare the smoker by rolling a piece of cotton rag and lighting one end. Having removed the nozzle, put in the smouldering rag, and work the bellows with the replaced nozzle pointing upwards until smoke comes out freely.

Carefully unscrew the lid of the box containing the swarm; then put on the veil, tucking it well inside the coat all round. Slowly lift the lid of the box, and with a jerk throw the bees adhering to it on to the slanting board. Put the lid aside and lift up the box of bees; then throw them out amongst the others with another sharp jerk. Now, take up a position by the side of the hive, with the smoker in the right hand, and if the bees do not at once enter the hive, give a puff or two of smoke, or throw some towards the entrance. It is most likely, however, that the bees will set up a pleasant hum, and at once proceed to enter their future home. A careful watch for the queen should be kept, for once she has entered the hive the bee-keeper need trouble no further for that day. Next morning if the weather is fine and warm, light the smoker and give a few puffs into the entrance of the hive, then in two or three minutes remove the roof. Gently lift off the woollen wraps, take away the empty feeder, give a puff of smoke over the hole to send any bees down, and gently peel off the calico, giving a few puffs of smoke as you do this. The bees will be found clustering on the frames, and if any are not well covered with bees they may be removed, the bees being shaken off first. If the bees are too crowded, a frame or two more may be added. The hive should be left alone for a few days, feeding to be continued if honey is not coming in freely. When next examined, several of the sheets of foundation will be found converted into combs, some containing a large number of eggs, if the queen was hived safely.

Stings. The only objection to bee-keeping is the risk of stings being received; yet the liability of being stung, and the pain resulting therefrom, have been greatly exaggerated. Frequently hive after hive can be examined without a single sting being received, but accidentally kicking a hive, jerking the frames, hurriedly drawing the hand away, or breathing upon the bees will frequently irritate them. When manipulating hives, all movements should be deliberate and gentle, and the smoker or carbolic cloth ought to be used until perfect confidence has been gained. The simplest thing to do when stung is to scrape out the sting with the finger-nail, care being taken not to pinch it with the fingers, for this sends more of the poison into the wound, then to apply a few drops of solution of potash, or of diluted liquid ammonia.

Reference has already been made to the use of the smoker for controlling bees, but carbolic acid is another most useful and cheap quieter. A carbolic cloth is made by cutting a piece of calico to the size of the top of the body-box, then sprinkling over it a solution of carbolic acid, one part of Calvert's No. 5 to three parts of water. The cloth should be rolled up and kept in a closely-fitting tin box; and when it is applied to the top of the frames for a few moments it will send the bees down between the combs.

Swarming, and the Fight of Rival Queens. The reason for swarms issuing has already been given. Let us see what takes place in a hive about the month of June, as this will help us to understand what artificial swarming means. When a hive is crowded with bees and brood, the bees prepare special cells for the queen to lay those eggs in which are to produce queens. These cells are a sure sign of a swarm being about to issue, and a further sign is when clusters hang about the entrance. When the queen cells have been sealed over, most of the flying bees fill themselves with honey, and some time after nine o'clock in the morning they pour out of the hive with the old queen, leaving the young bees to care for the remaining unsealed larvæ.

If by accident there should be two queens in a hive they fight for supremacy, the victor stinging her rival to death. When one of the queens hatches out of the cell she makes an effort to destroy rivals in other queen cells. If the hive is very strong the bees may prevent her doing so, in which case she often makes a piping sound, and the next day, if fine, she leaves the hive with most of the flying bees, these being called a "cast," not a "swarm." The same may happen when other queens hatch out, thus weakening the hive; in order to prevent this, after the swarm has issued, each frame of brood must be carefully examined and the point of a penknife stuck through each queen cell with the exception of the largest and best shaped. If other hives are queenless, the queen cells may be cut out and inserted between the frames of these hives, taking care that the cells hang downwards where the bees are most crowded.

Taking and Making Swarms. Swarms should be taken late in the afternoon, though if the sun is shining upon the bees in the daytime, a temporary shade must be rigged up. The taking of a swarm is quite a simple affair. Place underneath it a large skep to receive the bees, then give one sudden jerk to the branch on which the swarm hangs, when most of the bees will drop in, and it is practically certain that the queen will be with them. If many fall about the ground, put the skep in its usual position on the ground, but propped up an inch on one side, when all the bees will go inside and cluster from the roof of the skep.

It is possible to make an artificial swarm. When the hive is crowded with bees from end to end, lift it to a new stand, and in its place put a fresh hive containing five frames of brood foundation wired, or five empty combs, leaving a space in the centre for a comb of brood and bees, on which must be the queen, to be taken from the old hive. Contract the size of this new hive by using a division board, and put woollen wraps on the top of the frames. These operations must be carried out in the middle of a fine day, when the bees are flying freely, and if honey is not coming in the swarm should be fed with several pounds of syrup. The bees that leave the old hive to gather honey and pollen will return to their old stand, and consequently enter the new hive, thus forming, with the old queen, the swarm. The young bees in the old stock soon become foragers, and large numbers of bees hatch out daily. This plan of artificial swarming saves much anxiety and waste of time in waiting for swarms to come off.

The Time to Begin Bee-Keeping. The most satisfactory time to begin bee-keeping is before the honey-flow, say early in May, for the return of honey is most encouraging to the beginner, and serves to counterbalance the pain and inconvenience caused by stings. If a swarm and a new hive are purchased at that time there is every prospect of a fair start being made without the inroad of disease; and if a stock with a young queen be purchased in the spring, it will be sure to give a good return of honey, provided the season and district prove favourable. But the cheapest way to commence bee-keeping is to buy driven bees in the autumn, when they can be bought for from 1s. 3d., or even less, to 1s. 6d. per lb. as against 2s. 6d. or more charged in May and June. As no honey is coming in then, the bees have to be fed freely, from 35 lb. to 40 lb. of syrup being given to 5 lb. of bees, if frames of foundation are provided. If empty combs are available, from 25 to 30 lb. of the syrup will be sufficient.

How to Obtain a Good Return of Honey. When left to their own devices, bees raise numbers of drones; and the more drones there are in a hive, the fewer will be the worker bees to gather honey, and the greater the amount of stores consumed. By the use of foundation, bees can be compelled to draw it out into combs in which workers will be raised. If left to themselves, stocks of bees may persistently swarm, with the result that there is a reduction in the amount of honey gathered, for weak stocks will not store surplus honey. If, however, such stocks are joined together, and are headed by a young queen, they will gather enough for their winter supply and a fair surplus in addition. Bee-keepers should remember that it is a far wiser policy to have three strong stocks than a dozen weak ones, because a strong stock will gather from 20 lb. to 60 lb. of surplus honey, or even more, according to the season and the district, whereas a weak one will gather only sufficient for its own consumption, leaving no surplus.

Honey is disposed of and eaten in two states—in sections (comb honey), and extracted from the comb (run honey). As the bees have to build the combs in sections, whereas in the case of extracted honey the combs can be used time after time, becoming stronger and more serviceable with age, it is evident that more run honey can be obtained from a given stock than section honey. On the other hand, the latter fetches a better price, it is more attractive, and in some cases it is more easily disposed of, for retail shops frequently prefer sections.

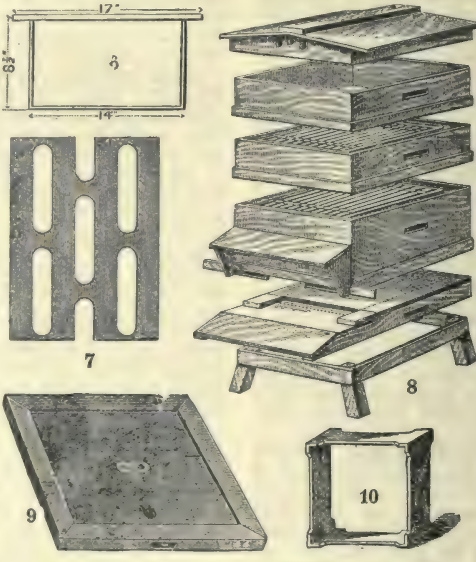
A Strong Stock. Let us now consider what must be the necessary condition of a stock of bees at the commencement of the honey-flow if a good return of honey is to be obtained. The hive must be a large one, holding from 10 to 12 frames, and these must be crowded with bees from end to end, and be almost full of sealed brood, larvæ and eggs. If, by assistance of frames from other hives, all combs contain chiefly sealed brood, so much the better. The fact should, therefore, be strongly impressed on the memory that the hive must be packed with brood and bees if a good surplus is to be gathered, in order that when the rack of sections or super of shallow frames is put on, the bees go up at once, glad of the extra space given to them. If they refuse to start work during the first few days of

the honey-flow, there will be a loss of honey at the rate of between 2 lb. and 3 lb. per day in each hive.

There are two kinds of supers—one holding shallow frames, from the combs of which honey is extracted, and the other containing 21 sections, each of which [10] should be furnished with a sheet of exceedingly thin foundation, which the bees build out into comb that can be eaten. The best time to place the super on a hive is when it is crowded with bees just before the honey-flow. If the stock is in a very forward condition, it may be wise to put on the super some time before the honey comes in freely, so as to give the bees more room; but only experience will show when to do this. When supers containing shallow frames are used, a sheet of excluder zinc [7] must be placed underneath between the body-box and the super, to prevent the queen from laying there. As a rule, the fault of beginners is to put on the super too early, thus interfering with the warmth of the brood-nest and checking the raising of brood.

Packing Supers. A point which requires the careful attention of bee-keepers is the packing of the supers to keep them warm. As they go on the top of the brood-nest, the supers must be well covered, first with a piece of calico or American cloth, and afterwards with woollen wraps to keep in the warm air; and they must also be well packed round the edges of the frames. If the super is chilly or draughty the bees will not enter it, and owing to carelessness in packing many a bee-keeper loses surplus honey.

When a section rack is two-thirds full, and honey is coming in freely, as shown by the bees pouring in and out of the hive, the rack should be lifted, and another put underneath, then all should be packed as warmly as before. The sections in the upper rack will be completed and sealed as the honey ripens, whilst the bees will set to work on the foundation in the lower section rack. Any partly drawn-out section at the end of the honey-flow should be kept for another year, since bees go up into the super much more readily when some of these "bait sections" are provided.



HIVE AND ACCESSORIES
6. "Standard" frame **7.** Excluder zinc **8.** "W.B.C." hive **9.** Super-clearer containing bee-escape **10.** Section to hold 1 lb. of comb honey

Removing the Honey. When it is necessary to remove the honey, the bees are made to leave the super by means of a super clearer [9], which does the work excellently. It is a board the size of the section rack, with a hole in the centre containing an ingenious contrivance called a "Porter" bee-escape [11], and by the use of this the super is quite clear of bees in under twelve hours, and can be lifted off the hive without any trouble.

If it is possible to leave run honey in the hive until it is sealed, its consistence will be much improved; but at times it has to be removed before it is thoroughly ripe, in which case the extracted honey must be placed in a honey-ripener [12] in a warm room.

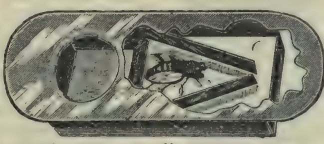
Extracting Honey. Extracting honey from the comb is carried out by an extractor [13], the cage of which revolves at a very rapid rate, throwing the honey to the sides of the extractor, when it slowly trickles down and runs out at a hole to which a tap is attached. The cappings of the combs on both sides have to be shaved off, for which purpose a Bingham knife, or a W. B. C. uncapping knife, should be used, and this has to be kept in hot water. When the combs have had the honey extracted from them, they must be given to the bees to fill again, provided the honey-flow continues, or to be cleaned up if the flow is over. In the latter case, they are placed on the top of the super-clearer, and the bees will clean the combs perfectly, carrying the honey below. The dry, empty combs should at once be tied up in packets to keep out moths, and kept in a dry, cold place. Three or four balls of naphthaline, split in two pieces, should be put in each parcel.

All pieces of comb ought to be put into a closed box, in order that moths may not be encouraged, and in spare moments these should be melted down. In the summer time this may be done in a solar wax extractor, but at other times the melting can be done in a steam wax extractor, which costs about 10s. Where there is only a small quantity of wax to be melted down, a little ingenuity will enable this to be done with home utensils. Many persons use a potato steamer, putting the pieces of comb in the upper part, and two inches of rain-water in the lower part, then standing it for a time in an oven not too hot.

Raising Queens. Queens will live for four or five years, but they should not be permitted to reign more than two years. There are two suitable times for re-queening hives—some time before the honey-flow, say, early in May in districts where the honey is chiefly obtained from the clover and lime, and after the honey-flow, about the end of July. The latter is the popular time, for then queens are cheap, and they can be raised quite easily. The method of re-queening a hive is very simple, for if the queen is removed, the bees will at once set to work raising others. Three days after the queen has been taken away the queen cells should be examined, and the two containing the smallest grubs should be left, the others being destroyed. In a week's time the two cells must be again examined, when the poorer one of the two should be destroyed. A queen cell is then put, hanging downwards, between the frames of each hive needing to be re-queened.

If it is not convenient to introduce a young queen to a stock, she may be kept in a nucleus hive, which is made by putting one frame of sealed brood and two frames of stores, well covered with bees, into a hive, the frame of brood in the centre; then contracting the size of the hive by means of division boards, and shaking into it the bees off two or three other frames, so that when all flying bees have returned to the parent hive, there will still be left a sufficient number to keep the brood warm. The division boards may be raised a quarter of an inch to allow any straggling bees to crawl under to join the others.

There is sometimes fear as to shaking bees from combs; but, provided the stock is smoked a little beforehand, in order to frighten the bees, and thus cause them to fill themselves with honey, there need be no apprehension. Bees in this condition can be shaken off the comb on to a sheet of newspaper, then rolled about and poured into the nucleus hive like so many currants. In shaking the bees from the frames there must be a sudden jerk, not a series of gentle shakes, or the bees will be irritated.



11. "PORTER" BEE-ESCAPE

Introducing Queens. A great deal of fuss is made about introducing queens; but, provided a hive has been queenless for forty-eight hours, a fertile queen will usually be accepted at night by lifting a corner of the quilt and letting her run down, a few puffs of smoke having previously been given. If all the brood is sealed, a virgin queen can be thus introduced. Some years ago Mr. Simmins found out the following excellent method of direct queen introduction. Remove the old queen at midday; then, when it is quite dusk, keep the new queen, which must be fertile, without food for half an hour. After giving a puff or two of smoke at a corner of the quilt, which has been lifted, let her run down between the frames. A hive should not be examined after the introduction of a queen for two or three days.

When manipulating hives, and especially when the honey-flow ceases, care must be taken that bees do not get what is known as the robbing fever. To prevent this, hives must never be kept opened, and syrup or pieces of honeycomb should not be left about. This caution is especially necessary when the surplus honey has been removed from hives, at which time weak stocks and nucleus-hives should have entrances so reduced that only two bees can enter at a time.

Wintering Stocks. One of the most important periods in the bee-keeping year is autumn, when the packing of the hives for winter has to be carried out. The essentials for safe wintering are strong stocks, ample stores—say 25 lb. to 30 lb. of sealed honey or syrup, plenty of woollen wraps, good ventilation, water-tight roofs, and passages for the bees above the combs. The last-mentioned are arranged by putting some pieces of $\frac{1}{4}$ in. sticks, or some twigs, across the frames, which should be spaced a little wider apart than usual. A hole should be cut in the calico so that a cake of candy can be placed on in the spring, if necessary. An important point to be borne in mind is that a young queen lays late in the summer, with the result that there are plenty of young bees to live through the winter ready for the hard work of spring, and she also begins to lay much earlier and more freely than an old queen. After being carefully packed for the winter, hives should not be thoroughly examined until the end of March; and if a peep under the quilts in February shows that the stores are running short, a cake of candy can be put over the feed-hole, and renewed as often as is necessary.

If stocks are increased by artificial or natural swarming, not much honey can be expected, excepting in very good districts or in unusually good years; therefore the bee-keeper must make up his mind which he requires, honey or stocks.

Feeding Stocks. An important feature of modern bee-keeping is feeding. Bees are fed in the spring, if there is not sufficient in the hive for their maintenance, or in order to stimulate the queen to lay freely; they are fed again in the summer if honey is not coming in quickly enough to provide food for the very large brood nest; and, lastly, in the autumn they have to be fed, if there is not the requisite amount of stores for the winter. In spring and summer the feeding should usually be what is known as slow, stimulative feeding, only three or four holes of the graduated feeder being used. In autumn the feeding has to be rapid, hence all the holes should then be used.

Granulated honey—that is to say, honey which has become more or less like candy, can be reliquefied by standing the pots in hot water—not boiling water, or the flavour of the honey will be spoilt. The granulation may sometimes be postponed by keeping the honey in a warm, dry place. Section honey which has become granulated can be put in a jar, stood in water sufficiently hot to melt the wax, when the honey will reliquefy, and the former can be taken in a cake off the top.

12. HONEY RIPENER

A Few Recipes. *Candy*—7 lb. loaf sugar (preferably Tate's No. 1), $1\frac{1}{2}$ pints of water, 1 teaspoonful of cream of tartar. Boil in an enamelled saucepan for a few minutes, keeping the syrup well stirred, and taking care that it does not burn or boil over. To test whether it has been sufficiently boiled, drop a little into a glass of cold water, when, if just right, the syrup will become like putty. When sufficiently boiled, remove the saucepan from the fire and place it in cold water; then stir the syrup for about 15 minutes, by which time it will become very thick. It can then be poured into soup-plates, in each of which a piece of paper must be put.

Syrup for Spring and Summer—To each pound of loaf sugar add three-quarters of a pint of water, a heaped saltspoonful of salt, and three-fourths of a teaspoonful of vinegar. Boil for a few minutes, taking care the syrup does not burn.

Syrup for Autumn—To each pound of Tate's No. 1 sugar add half a pint of water, three-fourths of a teaspoonful of vinegar, and a small saltspoonful of salt. Boil for a few minutes without burning.

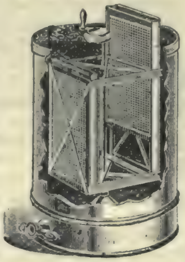
Beta-naphthol Solution—It is wise to medicate all food with beta-naphthol solution, in case foul brood should be introduced into the hives. The mixture is made as follows: Put some methylated spirit into an 8-oz. bottle, add 1 oz. of beta-naphthol, which will cost 6d. or a little over at the chemist's, shake the bottle well, then fill up to 8 oz. with spirit. A teaspoonful of the mixture is the proper amount for each $2\frac{1}{2}$ lb. of sugar,

and it should be added when the saucepan has been taken off the fire, after which the syrup should be well stirred.

Carbolic Acid Solution—This is made by shaking well one part of Calvert's No. 5 carbolic acid with two parts of water for disinfecting hives, and one part of the acid to three parts of water for sprinkling on the carbolic cloth for quieting the bees.

It is wise to keep naphthaline constantly in the hive, the proper dose being two balls split in two, and the pieces should be put as far as possible from the entrance.

The Commercial Side. Now let us estimate the actual profits of bee-keeping, which vary according to the locality, the season, and the ability of the bee-keeper. Taking a fairly good locality, and a person with a thorough knowledge of the work, an average profit of from 7s. 6d. to 12s. 6d. per hive may reasonably be expected. Of course, in some years far more than 12s. 6d. per hive will be obtained, whereas in others there may be but little surplus, owing to bad weather. The figures given do not refer to just two or three strong hives, but to the average of a number, both strong and weak.



13. HONEY EXTRACTOR

Another profitable branch of the business is the selling of swarms, stocks, and nuclei. Swarms are sold at from 10s. 6d. to 15s., but it is a good plan to have a fixed price per lb. Stocks of bees, if bought in March or April, will cost about £1, and with proper attention a strong stock with a young queen purchased then can be converted into two strong stocks by the autumn.

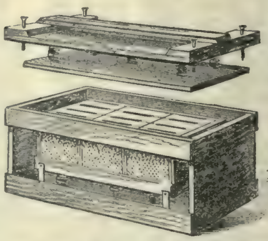
Queen-raising as a business is remunerative, but requires more than average knowledge and skill. As queens are sold for about 7s. 6d. in April, 5s. in May and June, 4s. in July, and for about 3s. afterwards, it will be seen that the profits are satisfactory, though none too great, bearing in mind the work, time, trouble and risk involved. Queen breeders who have a good connection are able to ask even higher prices than those mentioned. It is not everyone who is able to handle queens, and it certainly requires a little knack to find them easily and to pick them up quickly by the wings. Queens are sent by post in cages containing three circular holes, in one of which is placed a mixture of honey and castor sugar well worked and of sufficient consistence not to run. In the other two holes the queen, with a dozen or more young workers, will keep in good condition as long as the candy lasts, and over these two holes a piece of wire cloth is put.

Storing and Packing Honey. Honey must be stored in a dry, warm place, in order to defer granulation, which always takes place in the case of pure honey, as long as possible. Sections must be packed in boxes or parcels to which moths cannot gain access. Ordinary biscuit tins will hold 16 sections, and these boxes will last a lifetime; or the sections can be packed in the empty racks, which should be tied up in paper. Run-honey should be bottled at once, otherwise granulation will take place when it is in a large receptacle; and it should be strained through two thicknesses of fine muslin, in order that it may be clear. A label stating that the honey is pure, and giving the name and address of the bee-keeper will help to increase the sale. Bottles of honey can be packed well in boxes containing divisions, with corrugated paper round each bottle, and at the top and bottom. Sections travel best in specially-made crates with springs to prevent the jerking of the honey [14]; but only dozens or two dozens can be sent in this way. Where large quantities have to be forwarded, sections should be tied up in paper in parcels of six, with a piece of wood the size of the section at each end, and packed in boxes with thick pads of straw at the sides, top, and bottom. The object of the tying in half-dozens is to limit the mess and the loss in case of an accident.

Marketing Honey. The essentials in making and keeping a market are to sell only high-class honey, to supply punctually, and to arrange that orders can always be executed. Small producers, as a rule, sell their honey privately, and by this means get the highest price; those who keep a number of hives must look for a wider field for the larger quantity they produce, and to those the retail shops will pay a good price for first-class honey—from 8s. to 9s. per dozen sections or pound jars. But those who keep a very large number of hives must be content to accept a lower price in view of the large quantities disposed of. The prices paid by the wholesale merchant vary from 7s. to 7s. 6d. per dozen for good sections; first-class run-honey in bulk ought to fetch 56s. per cwt.

It is necessary to grade sections and run-honey, and the former can usually be divided into three classes. The first should be of full weight, well sealed, and of good colour; the second ought also to be of good weight, though not so well finished off; the third grade, under 1 lb. in weight, should not be sold, since they bring discredit on the honey trade. All sections should be scraped clear of propolis. Run-honey also needs to be graded, only that of good consistency and colour being sold. Sometimes it is of an exceedingly dark colour, especially when there is an admixture of what is known as "honey dew"; but this should never be sold. It can be fed back to the bees.

It is a bad policy to place quantities of honey on the market in good seasons, since this tends to lower the price, to the detriment of honey producers in general. The greatest sinners are those who keep a few hives, when in a good season they secure a hundred or two sections. Fearing that the honey will be left on their hands, they offer the sections at a ridiculously low price to local shopkeepers. If put in a warm, dry place, sections will, as a rule, keep for a long time, and there is no necessity to hurry to place them on the market.

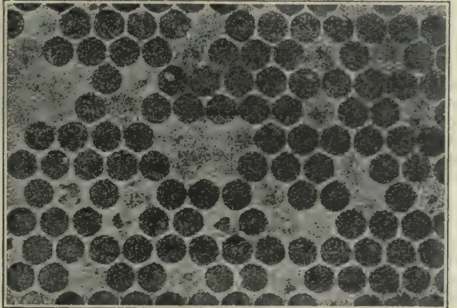


14. SPRING CRATE FOR MARKETING HONEY

Bee-keeping Expert's Certificate. Those who intend to go in largely for bee-keeping should work up for an expert's certificate, which can be obtained from the British Bee-keepers' Association in three grades. A holder of the lowest certificate—the third class—can be depended upon to be a thorough practical bee-keeper; the second and first-class certificates are awarded to those who have a higher scientific knowledge of the subject. With the

interest which is now being taken in modern bee-keeping by county councils, experts are in request by bee-keeping associations, and there is every reason to expect that facilities for lecturing on this subject in bee tents, as well as for teaching, will increase year by year. There is a scarcity of really good experts for the work referred to, and the higher remuneration which will be given as more interest is created in the subject will without doubt cause an improvement in the class of person willing to qualify. Another part of the expert's work in some districts is the driving of bees for cottagers in the autumn. In spite of the efforts made by bee-keeping associations in country districts, bees are sometimes killed for the sake of the honey, and in these cases experts drive the bees from the skeps, keeping them for their trouble, or only paying a nominal sum, and giving the owner the honey. These driven bees fetch a good price, 1s. 6d. per lb. being obtained in August, and from 1s. 2d. to 1s. 4d. per lb. in September.

Diseases of Bees. The most troublesome disease in bee-keeping is that known as "foul brood" [15] or "bee pest," which attacks chiefly the larvæ, with the result that they die in numbers and rot in the hive. In due course the diseased material in the cell dries up, the bacilli become spores, and these, when they find a suitable medium, re-develop into bacilli, and so the cycle goes on until all spores and bacilli are absolutely destroyed. Healthy larvæ are of the same colour as the eggs, and lie curled up at the bottom of the cells; but some bee-keepers have at times a little difficulty in telling whether dead ones are diseased or have succumbed to cold. It should be remembered that chilled larvæ are at first of a greyish colour, and then turn somewhat black, whereas diseased ones are at first of a straw colour, and then turn brown. Dead, diseased larvæ can be drawn out of the cells in long, stringy pieces if a match be inserted: and when a stock is badly diseased, very many of the sunken cappings of the cells will have a small hole in them. An experienced bee-keeper can frequently tell a case of foul brood from the smell, which may sometimes be detected some distance from the hive. To prevent the inroad of this disease, the bees must be kept strong, with a young queen, say, not more than two years old; the hive must be kept clean, the floorboard being regularly washed every year; the combs must not be allowed to get too old, and when the bees are fed, the syrup should be medicated with beta-naphthol solution. The cure of a diseased stock is not a difficult matter. Shake the bees off the combs into a large box, sometimes called the "hospital box," which must have openings 2 in. wide covered with strips of perforated zinc each side right along the box, with another strip along the lid. Confine the bees in this box for forty-eight hours, giving them, after twenty-four hours, medicated syrup; thus all the diseased honey will be consumed. Destroy the frames and coverings, and have the hive well scrubbed out with hot water, using plenty of soap. When it is dry, paint it with a strong solution of carbolic acid and water—one part of Calvert's No. 5 to two parts of water. Care must be taken that the liquid does not touch the hands, and that drops do not fly into the eyes, as it burns acutely. Expose the hive to the air, and at the end of forty-eight hours put in fresh frames and introduce the bees, feeding for a while longer with the medicated syrup. The Board of Agriculture's leaflet No. 32 gives fuller particulars of this disease.



15. FOUL BROOD IN AN ADVANCED STAGE

Dysentery and Spring Dwindling. A disease which is not nearly so common, though from time to time it is met with, is dysentery. This frequently occurs through giving the bees unwholesome food, especially when they cannot leave the hive owing to bad weather. The bowel becomes distended, and the bees void excrement over the combs. To cure them, give a clean hive, fresh combs, and either properly-sealed stores or candy. Disturb the bees afterwards as little as possible, but wrap up the hive warmly.

Spring dwindling, which is spoken of as a disease, is usually the result of bad management. It is caused by the bees dying at a more rapid rate than that at which the new ones are being raised. The mortality of bees is always great, but in the spring it is essential that care should be taken to prevent cold winds and wet days carrying off an abnormal number of bees. Alighting boards should be provided, so that tired bees may not be lost; in very windy quarters the hives should be sheltered; and peaflour sprinkled on straw with shallow pans of water should be placed in sheltered situations near the hives. The best preventive of spring dwindling is a young queen.

Insurance and Journals. Thanks mainly to the efforts of Mr. T. I. Weston, vice-chairman of the Council of the British Bee-keepers' Association, there are now facilities for insuring against loss as a consequence of bees stinging persons and animals outside an apiary. The danger of being mulcted in damages has always been a sore point with bee-keepers, but now, for the payment of one penny per hive, with a minimum payment of 9d. for members of bee-keepers' societies, owners of hives are protected to the extent of £30. Full particulars can be obtained from the Secretary of the British Bee-keepers' Association, 12, Hanover Square, London, W.

All bee-keepers should endeavour to join a bee-keepers' association, and those who are unable to belong to a local one should join the British Bee-keepers' Association, which is the parent society. Those who wish to make real progress in bee-keeping should read regularly bee-keeping periodicals. The "British Bee Journal" is published weekly at one penny, and the "Bee-keepers' Record" issued monthly at 12, Hanover Square, W., for twopence. A very useful book is Cowan's "British Bee-keepers' Guide-book" (W. B. Carr, 8, Henrietta Street, W.C.).

BEE-KEEPING *concluded; followed by* GARDENING

Group 29
TRANSIT
28
SHIPBUILDING
continued from page 5924

PRINCIPLES OF SHIP DESIGNING

General Conditions. Equilibrium of Floating Bodies. Calculation of Areas, Volumes, Displacement, and Stabilty of Ships

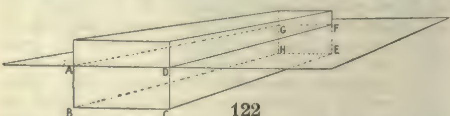
By Dr. J. BRUHN

WHEN a ship is required, it is usual for the intending owner to approach a builder and ask him to construct a vessel fulfilling certain specified conditions. These will, as a rule, be quite sufficient to determine the character of the vessel, and will thus enable the designer to proceed with his work, but the owner's specified requirements presuppose nearly always certain fundamental conditions, which all vessels, whatever their purpose, must fulfil. In the first instance, all ships must be able to float on the water, they must be able to float in the upright position, and they must possess sufficient structural strength to float without receiving injury to the hull. The duty of seeing that the last condition is fulfilled is, for sea-going vessels, usually relegated to one or other of the societies looking after the insurer's interests. The designer's primary concern is, therefore, that the vessel will float and float upright.

The Owner's Requirements. The prospective owner will probably lay down conditions as to the cost, the cargo-carrying ability, the amount of space available for cargo or passengers, and he may also specify the maximum draft at which the cargo is to be carried as well as the speed and the coal consumption, and very likely he may also limit in some way the principal dimensions of the ship—that is, the length between perpendiculars and the breadth and depth moulded. It is the duty of the designer to see in the first instance whether the problem of producing a ship fulfilling all these specified conditions is at all capable of solution. It will often be found that all the wishes of an owner cannot be met. It is therefore desirable that a certain amount of latitude should be left to the designer in dealing with the various problems placed before him. It will then be his duty to effect a compromise between the many conflicting conditions, and to produce what will be on the whole the most satisfactory ship from the owner's point of view. It will easily be understood that each of the owner's requirements usually tends to increase the difficulties of the designer. It is an easy task to design a ship that will float; it is a more difficult one to design one that will carry a given amount of cargo, and a still more difficult one to construct a vessel that will carry the required cargo without exceeding a certain specified draft. From the owner's point of view the cost of the ship will usually be the primary condition, and it will at once place a very rigid limit on the possibilities of the design.

Cargo-carrying Capacity. The next important requirement of the owner will probably be the insisting on a certain amount of cargo being carried. This may, however, often amount to the same condition as the previous one, as the price of the vessel may be arranged at so much per ton of weight carried. The amount of cargo that a ship can carry is called its *dead weight capacity*, and it is usually measured in tons at 2,240 lb. It will be easily understood that the size of the vessel to be designed must depend on this quantity of cargo to be carried, but it will also largely depend on other requirements, such as size of engines and boilers, coal capacity, passenger accommodation, etc. The first point the designer must settle is the size of the vessel, not only as determined by its length, breadth, and depth, but also as represented by its total weight. For the same description of vessel the cost will vary as the total weight of the complete and loaded ship. The weight of a ship, or the *displacement*, as it is called, represents the amount of raw material at the designer's disposal, and it remains for him to apportion it in such a way to the hull, machinery, outfit, etc., that the owner's requirements are satisfied in the most efficient manner. The estimate of the weight of a ship is therefore one of the first and most important tasks of the designer.

Weight of Floating Bodies. It is, of course, a well-known fact that many objects remain floating on the surface when thrown in the water. A log of wood, as shown by **122**, will sink into the water a certain distance until, say, the portion ABCDEFGH is below the level of the surface, and it will then remain floating at that position. It will be seen that as there is equilibrium the wood must press downwards on the water to the same extent as the water presses upwards. The downward force of the log is simply its weight, and the aggregate upward pressure of the water must therefore be equal to the weight of the object floating on it. The log of wood may now be imagined removed and space ABCDEFGH filled with water. It will be clear that this would not disturb the equilibrium of the surrounding water, which would still press upwards with exactly the same force as before. The water in the space ABCDEFGH must therefore also press downwards with a force equal to that of the removed log and the aggregate downward pressure of this water is equal to its weight. In other words, the weight of the water in the space ABCDEFGH, or the water displaced by the log, is exactly equal to the weight of the log. This may be stated generally as follows—*the weight of every floating object is equal to the weight of water which it displaces.* If, therefore, the log of wood [**122**]

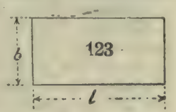


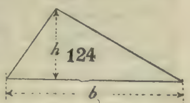
122

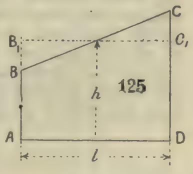
is inconveniently large to be weighed directly, its weight may be estimated by measuring up the volume ABCDEFGH, say, in cubic feet, and then multiplying it by the weight of a cubic foot of water. The weight of one cubic foot of ordinary sea-water is $\frac{1}{35}$th of a ton, and the weight of one cubic foot of fresh water is $\frac{1}{36}$th of a ton. A ship is, of course, too large an object to weigh directly, and to weigh actually or to estimate directly the weight of each of its separate items is a very laborious process, and one that could not be depended upon for accuracy. The weight of a ship is therefore always estimated by calculating the weight of water it displaces, which is a fairly simple and exact

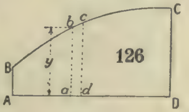
operation to perform, requiring only proficiency in the calculation of volumes of irregular shape.

Calculation of Areas. Before explaining how volumes are calculated it is, however, necessary to deal with the estimating of areas, which is also in itself necessary in naval architecture apart from its use in connection with volumes. The estimating of the area of a plane rectangular form as **123** is very simple, as the product of its length, l, and its breadth, b, will represent the required quantity. The area of a triangular form [**124**] is equally easily calculated, being one-half the product of its height, h, and base, b. It will be seen that the area of the trapezoidally-shaped figure ABCD [**125**] is equal to the rectangularly shaped area AB_1C_1D, where AB_1 and DC_1 are equal to the mean of AB and DC. The area of a trapezoidally-shaped figure, therefore, is the product of the base, AD, and the mean height, $\frac{AB + CD}{2}$.



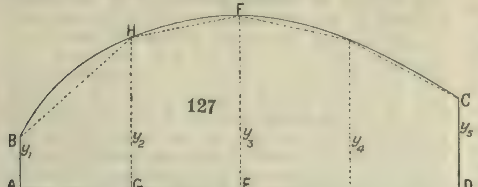






When the figure is of the form shown by **126**, its area cannot be estimated so readily as in the three former instances on account of one of its boundary lines, BC, being curved. AB and CD are supposed to be at right angles to the base. If the exact form of the curve BC can be mathematically defined, it may be possible to obtain a mathematically exact expression for the area ABCD, but as the curves dealt with in naval architecture are never mathematically defined, it would be of no use to have exact expressions for the areas bounded by them. It is therefore necessary to employ so-called approximate methods, which may, however, enable the area to be calculated with as high a degree of accuracy as the curve BC itself can in practice be known and drawn on paper. There are several of these approximate formulæ for the estimating of areas of irregular form.

The Trapezoidal Rule. The simplest is the trapezoidal rule. In using it, the base of the area AD is divided up into any number of equal parts and ordinates y_1, y_2, etc. Figure **127** is erected at the points of division. The area of the figure is then supposed to be represented by half of the sum of the length of the end ordinates plus the sum of the remainder of the ordinates, the whole being multiplied by the common interval, or, if the area is A, then:



$$A = (\tfrac{1}{2}y_1 + \tfrac{1}{2}y_5 + y_2 + y_3 + y_4)\,h.$$

A superficial examination of this expression will show that it is obtained by estimating the area of each of the trapezoidally-shaped portions by the above-described method and then adding all the results together.

It will be observed that instead of having five ordinates as shown in **127**, the number might have been any one from two upwards. The difference between the area calculated in this way and the actual area is represented by the portions lying between the curve BC and the straight lines joining the heads of the ordinates y_1, y_2, y_3, etc. This difference represents, therefore, the error in estimating the area by the trapezoidal rule.

The actual area will always be a little in excess of the calculated one in the case of convex curves, but it will be seen that by halving the intervals, or, more generally, by spacing the ordinates closer, the error will be reduced. This rule is in many cases quite satisfactory for the calculation of areas in naval architecture, particularly when the intervals between the ordinates are taken small enough. It has the advantage of being simple in its application.

Simpson's Rules. Another formula, called Simpson's first rule, is, however, more commonly employed by naval architects in spite of the fact that it is somewhat more laborious to use. The base of the area to be measured is, as before, divided up into parts of equal length, h [**127**]. If the curve BF is part of a common parabola, the exact area of ABFE is

$$\frac{h}{3}\,(y_1 + 4y_2 + y_3).$$

In the same way the area of EFCD is

$$\frac{h}{3}\,(y_3 + 4y_4 + y_5),$$

if FC is a parabolic curve. Combining these two expressions the area of ABCD is

$$A = \frac{h}{3}\,(y_1 + 4y_2 + 2y_3 + 4y_4 + y_5).$$

All ship curves are practically parabolic ones, and it is therefore possible to employ this method of estimating the areas with a considerable degree of accuracy, even where the interval between the ordinates is a fairly wide one. It will be seen that the expression given above can be extended to any even number of intervals, the rule being simply to multiply the first ordinate by 1, the following ones by 4 and 2 alternately, and the last one by 1, then add these products together and multiply by one-third the common interval. By another formula, called Simpson's second rule, the area is

$$A = \frac{3h}{8}\,(y_1 + 3y_2 + 3y_3 + 2y_4 + 3y_5 + 3y_6 + 2y_7, \text{ etc.}),$$

where h is, as before, the common interval and y_1, y_2, y_3, etc., ordinates erected at the points of division. This rule is not so often employed, and it can be used only where the number of intervals is a multiple of three.

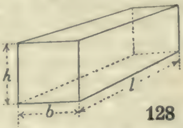
Other Rules. It sometimes happens that the area between two consecutive ordinates as between y_1 and y_2 has to be separately estimated. This is done by the so-called 5–8 rule. The area ABGH is, by this formula,

$$A = \frac{h}{12}\,(5y_1 + 8y_2 - y_3),$$

or one-twelfth the interval multiplied by five times the first ordinate plus eight times the second one and minus the third ordinate, which is at some distance from the area under calculation, but the length of which, of course, has influence on the form of the curve from B to H when the part BHF is supposed to be parabolic. It will now be

seen that the area between any ordinates whatever can be estimated by these three rules.

There are other rules, but those mentioned are quite sufficient to deal with all the problems that may arise in naval architecture, and it is necessary that students should commit them to memory as they have to be used over and over again. There are also mechanical contrivances called *planimeters* whereby areas are conveniently estimated by merely tracing the boundary of the figure by a pointer, the magnitude of the enclosed area being then read off on a moving scale. These instruments work very accurately, and are extensively used in ship calculations, where they save a considerable amount of time and trouble, but when they are not at hand it is necessary to use one of the approximate formulæ.



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Calculation of Volumes. The volume of a rectangular prismatic solid [128] is represented by the product of its length, breadth and height. The volume of a body with an irregular surface, as shown by 129, is estimated in the following manner. It is first divided up by parallel equidistant planes such as ABCD, EFGH, and IKLM. The area of each of these planes is estimated by means of Simpson's rule as previously explained, the area of the first one being

$$\frac{h_1}{3}\,(y_1 + 4y_2 + y_3),$$

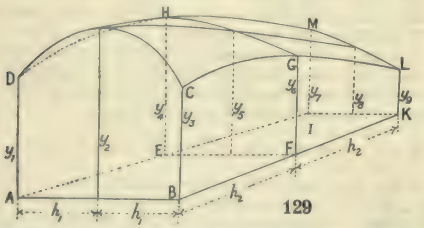
of the next one

$$\frac{h_1}{3}\,(y_4 + 4y_5 + y_6),$$

and of the last one

$$\frac{h_1}{3}\,(y_7 + 4y_8 + y_9).$$

All these areas are, in this instance, of equal width, and the interval, h, between the ordinates is therefore the same in the three cases, but it will be clear that their areas could equally easily have been estimated, if they had been of varying widths, by



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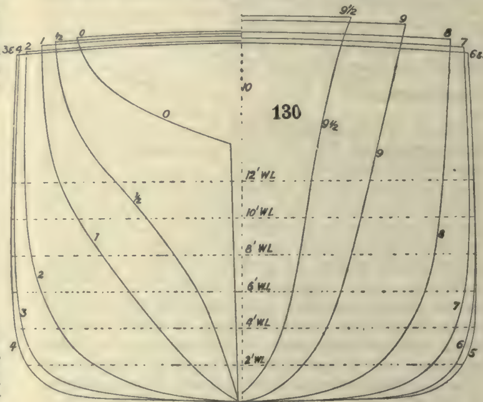
merely varying the interval between the ordinates. The area of a figure as ABCD [126] may be looked upon as made up of little strips like *abcd*, the area of which is the length of the ordinate y multiplied by the width of the strip n. The sum of all these strips represents the total area. In the same manner the volume of the body [129] may be supposed to be made up of little slices like that represented by the plane EFGH and the adjoining plane, and the sum of all the slices represents the total volume. When the areas of the cross section planes like ABCD, EFGH, etc., have been determined, they may be looked upon as ordinates of a curve with the basis equal to AI or BK, the common interval being h_2. The summation of all the little slices of volume is therefore equivalent to the summation of the narrow strips of a curve, the ordinates of which represent the areas of the cross sections. The volume of the solid [129] will therefore be

$$V = \frac{h_1 h_2}{9}\{y_1 + 4y_2 + y_3 + 4\,(y_4 + 4y_5 + y_6) + y_7 + 4y_8 + y_9\}.$$

Calculation of the Displacement of a Ship. For the purposes of calculations, the under-water part of a vessel is supposed divided up by water-line planes usually parallel to the keel and spaced 1 ft. to 4 ft. apart according to the draft, and also by parallel cross sections at right angles to the middle line plane and spaced 10 ft. to 30 ft. apart according to the length of the vessel. Care must be taken in arranging the position of these divisional planes that the number of intervals between them is suitable to the application of the summation rule to be employed. Figure 130 shows the cross sections selected for the purpose of calculating the displacement of a ship. They are produced from the vessel's line drawing described in an earlier article. The length of the vessel is first divided up into suitable intervals on the water-line or half-breadth plan. At the points of division lines are drawn at right angles to the centre line



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The intersections of these lines with the water-lines will give the half breadths at the water-lines for each of the cross sections wanted, and these can therefore be readily drawn. The body plan thus produced is similar to the proper body plan previously described, but the sections of the one will rarely correspond to the sections in the other. The volume of displacement—that is, the volume occupied by the immersed part of a ship—may now be calculated in two ways. Either the areas of all the cross sections may be first estimated, and they may then themselves be put through Simpson's rule and the required volume thereby determined. This is the simplest method, if the displacement is required only up to one particular water-line. In this case the areas of the cross sections can be conveniently estimated by a planimeter, but the subsequent operations are best carried out by the use of Simpson's rule.

Displacement by Water-line Areas. If the displacement is required to be estimated for various drafts, it is most convenient to calculate first the areas of the water-line planes and then pass these through the summation rule to obtain the volume. In this instance it is generally impossible to use a planimeter, as the water-line planes are too large for ordinary instruments. These areas must therefore be estimated by first measuring off the ordinates or half

breadths of each water-line at the respective cross sections, recording these in tabulated form and passing them through Simpson's rule by multiplying them by the factors 1, 4, 2, 4, etc. The products are then summed up and the result multiplied by one-third; the fore-and-aft spacing of the cross-sections represents the area of that particular water-line when multiplied by two for both sides of the ship being alike.

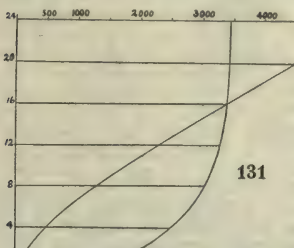
The following table shows the area worked out for the 12-ft. water-line.

No. of section.	Half-breadths.	Simpson's multipliers.	Products.
	In feet.		
0	·3	1	·3
1	10·0	4	40·0
2	12·0	2	24·0
3	12·6	4	50·4
4	12·7	2	25·4
5	12·7	4	50·8
6	12·7	2	25·4
7	12·4	4	49·6
8	11·0	2	22·0
9	7·0	4	28·0
10	·1	1	·1
			$316{\cdot}0 \times \frac{24 \times 2}{3}$
			= 5,056 sq. feet.

The area of any one of the water-line plans may be estimated in the same manner.

Curve of Displacement. When a ship is being designed, while she is being built, and during her subsequent life, it will be necessary to know what the exact displacement is under various conditions of loading. It will easily be seen that when the draught of the vessel is known, then the displacement is fixed, because the uppermost water-line is in that case determined, and thereby the volume of displacement. As the draught increases so the displacement will become larger, but the two quantities will not be in any given ratio. It would be impracticable to estimate the displacement directly for all the various draughts at which it may be required to be known. It is therefore calculated for certain draughts conveniently selected to agree with the water-lines on the displacement body plan [**130**].

A curve, called the *displacement curve* [**131**], is then drawn. A vertical scale of feet represents the draught, and at the selected water-line the displacement corresponding to the volume below that line is set off to some convenient scale at right angles to the draught line. When that has been done for all the water-lines, a fair curve is drawn by means of a batten through the points thus obtained. This curve has the property that the displacement of the vessel can be found for any immersion by setting off the draught on the vertical scale, and drawing a horizontal line corresponding to the given water-line. The length of this line, which is intercepted between the vertical line and the displacement curve, will, when measured on the proper scale, give the displacement at that draught.



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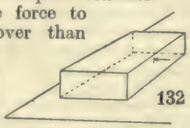
Displacement of Various Draughts. It will now be seen why it is advantageous to estimate the area of the water-lines first in calculating displacement, because when they are all known the volumes of displacement can be easily estimated up to any one of the water-lines. Let A_0, A_2, A_4, A_8, A_{12}, etc., be the areas of the water-line planes at draughts of 0, 2, 4, 8, 12 ft., etc. The volume of displacement below the 2 ft. water-line is then found by putting A_0, A_2 and A_4 through the 5-8 rule, and multiplying by $\frac{1}{12}$th the interval—in this instance 2 ft.—and by 2 for both sides. The volume below the 4 ft. water-line may be estimated by putting A_0, A_2, and A_4 through Simpson's first rule. The volume up to the 8 ft. water-line may be found by first estimating that between the 4 ft. and 8 ft. water-lines by the 5-8 rule applied to the areas of the 4 ft., 8 ft., and 12 ft. water-lines, and then adding it to the volume already calculated up to the 4 ft. water-line. The volume up to the 12 ft. water-line may be estimated by putting the areas of the 4 ft., 8 ft., and 12 ft. water-line planes through Simpson's rule, and adding the volume to that below the 4 ft. water-line. It may, however, be found more directly by multiplying all the water-line areas up to, and including, that of the 12 ft. line by suitable multipliers. If the common interval of the water planes be taken as 4 ft., it will be seen that the following multipliers may be derived from Simpson's rule by a simple combination—namely, $\frac{1}{2}$, 2, $1\frac{1}{2}$, 4 and 1 for the 0 ft., 2 ft., 4 ft., 8 ft. and 12 ft. water-lines respectively. In this way the displacement may be calculated for each of the given water-lines. The following table shows the detailed working out of the displacement up to the 12 ft. water-line:

No. of water-line plane.	Area of water-line plane.	Simpson's multipliers.	Products.
12	5,056	1	5,056
8	4,950	4	19,800
4	4,500	1·5	1,750
2	3,400	2	7,200
0	0	·5	0
			$38{,}806 \times \frac{4}{3} =$
			35) 51,740 cubic feet
			Displacement = 1,480 tons.

Spacing of Water-lines and Tons per Inch Immersion. It is usual to have the lower water-lines closer spaced than the upper ones. The reason for this is that the nature of the surface of the bottom changes very rapidly here, and for the same degree of accuracy a closer spacing of the water-line planes is necessary here than elsewhere. It will be easily understood that the displacement curve is most useful to designer, builder and owner alike. The first will be able to make estimates for the amount of dead weight that can be carried, with any given weight of hull and machinery. The second will be able to see from his estimated weight what the draught of the vessel will be when she is launched, and when the engines and boilers or any other weights are placed aboard her, and the owner will be able at any time to see at a glance what his vessel will carry at any given draught, or what the draught will be at any given load that has to be carried.

Another curve is usually drawn to the same scale of draught as the displacement curve for the purpose of estimating more exactly than is possible from the latter curve the addition to the draught due to a comparatively small weight being placed on board. This curve represents to some convenient scale the number of tons that it will take to immerse the vessel 1 in. at the various water-lines. It will be seen that the volume of displacement corresponding to this weight will be equal to the area of the water-line plane in question multiplied by the extent of the immersion—that is, by $\frac{1}{12}$th of 1 ft. The resulting volume divided by 35 will give the number of tons required to immerse the vessel 1 in. in salt water when floating at that particular water-line. Figure **131** shows such a curve of tons per inch immersion. As in the case of the displacement, the weights are set off at right angles to the scale of draught.

General Conditions of Stability. Knowing the weight of both ship and cargo, the designer can now always say if she will float, and in that case at what draught it will be. He must, however, also be able to decide whether she will float upright or not. This question of the stability of ships appears on the surface of it very intricate. In reality it is less so than the question of the stability of structures on land, if the latter is looked into a little less superficially than is usually the case. The stability of a structure is its ability to resist actions tending to overturn it. If a log of wood is lying on its side on the ground, as in **132**, it will be obvious that it will require considerably more force to turn it over than if it is standing on end as in **133**. In the latter instance a gust of wind might blow it over. It will further be obvious that the resistance to being overturned will increase with the weight and the breadth of the base of support. To investigate the conditions governing the stability of bodies, it is better to deal with a somewhat more general form, as that shown in **134**. Let this be a stone resting on the ground. Its weight will then exert a downward pressure on the earth, causing a slight cavity to be formed in it. The resultant force of the weight will act through the centre of gravity of the stone, and may be represented by a large arrow pointing downwards through the point G [**134**]. The earth, on the other hand, will exert an upward pressure on the stone exactly equal to the weight. As the weight is distributed through the entire stone, and has a resultant acting through its centre of gravity, so the pressure of the earth is spread over the base upon which the object is resting, and is more or less normal to the surface of the stone, while it varies roughly in intensity with the amount of depression below the original level. The resultant of this upward pressure must, when there is equilibrium, pass through the centre of gravity of the stone.



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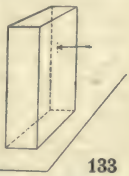

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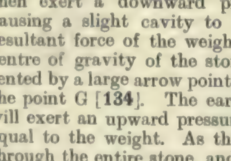

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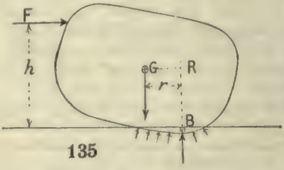
Stability of Objects on Land. Let now a force, F, be applied to the upper left-hand edge of the stone sufficient to cant it, as shown by **135**. The effect will be that the centre of gravity is raised somewhat, and the cavity in the earth caused by the pressure of the stone moves towards the lower right-hand edge. The amount of the upward pressure of the earth will, as before, be equal to the weight of the stone. The resultant of the earth pressure will, however, no longer pass through the centre of gravity of the stone. The moment tending to upset the stone is represented by the product of the force, F, and the height, h, of its point of application above the ground. The moment resisting the overturning is clearly the weight of the stone, say W, multiplied by the distance r between the vertical lines through the centre of gravity of the stone, G, and through the centre of pressure, B. The extent to which the vertical through the centre of pressure moves for a given amount of inclination will depend on the form of the stone where it touches the ground.



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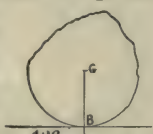
If the shape of this part is circular, with the centre of the circle coinciding with the centre of gravity, as shown by **136**, then a superficial examination will show that if the object is canted to the right, the centre of pressure, B, will move to the right, but the centre of gravity, G, will always move at the same rate in the same direction, and will remain immediately above B. There will, in that case, be no moment resisting the upsetting tendency, and the body will remain in neutral equilibrium in any inclined position. If, on the other hand, the form of the bottom is more flat—say, part of a circle with a larger radius, so that its centre, C, is above the centre of gravity, G [**137**]—then the point of support, B, will move more rapidly to the right, and there will be a resisting moment tending to turn the body back to its original position. In other words, the object is in stable equilibrium. But if the bottom is more curved, so that the centre, C, of the circle is below the centre of gravity, G [**138**], then the point of upward pressure, B, will move more slowly to the right, with the result that the G gets beyond it, and creates a moment upsetting the body, which would in that case not be in stable position. If it was in equilibrium to start with, the slightest touch would result in its being overturned. From these examples it is therefore seen that a body resting on the ground will be in stable, unstable, or neutral equilibrium according to the centre of curvature of its lower surface being above, below, or just at the centre of gravity.



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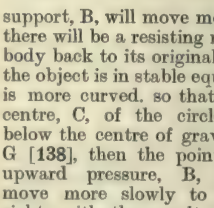

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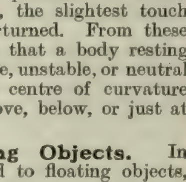

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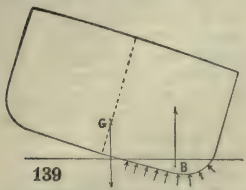
Stability of Floating Objects. In passing from objects on land to floating objects, there is no change whatever in the general conditions which govern the stability. The relative

positions of the centre of gravity of the object and the centre of pressure determine in both cases whether the body will be in stable, unstable, or neutral equilibrium.



139

Let **139** represent a very light vessel, slightly inclined to the vertical. The centre of gravity, G, will, as before, be the point through which the force of gravity acts downwards. The centre of the upward pressure of the water is determined as follows. Figure **140** shows the immersed portion of the vessel on a large scale. As it is only the vertical pressure with which we are concerned, it is necessary to consider only this component of the normal fluid pressure on the surface of the vessel.

140

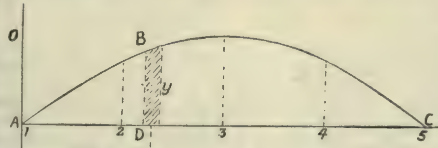
The vertical pressure at any point will clearly vary as the depth of that point below the surface. At M the pressure per square foot will thus be represented by a column of water 1 sq. ft. in section, and equal in height to MN. Adding together all these little columns, the total upward pressure is obtained, which, of course, must be equal to the weight of the vessel. The resultant of all the pressures will pass through the centre of gravity corresponding to the water displaced. This point, B [**139** and **140**], the centre of the volume of displacement, is called the *centre of buoyancy*.

Centre of Gravity. When the position of the centre of gravity, G, is known, it is necessary to determine only that of B in order that the stability of the ship may be known. In the case of solids resting on land, this point is near the surface of the body.

When the body is floating the point is at some distance from the surface. It is usually situated considerably further into the vessel than shown in **139**, owing to the water-line being much higher, and this is the only difference between the sea and land conditions governing the stability of an object.

The centre of gravity of a ship is the common centre of all the component parts—hull, engines, boilers, etc., and it might be determined by the usual calculations for determining the common centre of several objects. This is an exceedingly lengthy and tedious operation where there are so many thousands of items as is the case in a ship. This point is therefore usually determined in another way, which will be described later on. In the meantime, it will be assumed that the position of it is known. The question of the stability therefore resolves itself into the determination of the centre of buoyancy or the centre of a volume.

Centres of Areas. The centre of an irregularly-shaped volume is estimated by means of Simpson's rule, much in the same way as the volume itself is determined. As in that case, it is necessary to deal in the first instance with areas. The vertical position of the centre of gravity of an area, as ABC [**141**], is estimated by first determining the moment and then dividing it by the area. Let DB be a strip of area of breadth b and length y. Its area will consequently be $y \times b$. Being practically a rectangle, its centre of gravity will be at the middle or at a distance of $\frac{1}{2}y$ above the line AC. The moment of a plane about a line is the product of its area and the distance of its centre of gravity from the line.



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The moment of the little strip about the line AC is therefore

$$y \times b \times \frac{y}{2}, \text{ or } \tfrac{1}{2} \times y^2 \times b.$$

It will be noticed that this expression is similar to the expression for the area, except that $\frac{1}{2}y^2$ is substituted for y. The entire area, it was seen, is the sum of all the little strips $y \times b$, and in the same way the entire moment will be the sum of all the little strips, when $\frac{1}{2}y^2$ is used in lieu of y.

The summation of these strips is done by the use of Simpson's rule in exactly the same way as when areas are determined by simply writing down y^2 in lieu of y, multiplying by 1, 4, 2, 4, etc., adding up and multiplying the result by one-third the common interval, and dividing by 2, as y^2 has been used in lieu of $\frac{1}{2}y^2$. The result is the moment of the area about the line AC. The distance n of the centre of gravity from AC is therefore equal to the moment divided by the area. With four intervals of h and five ordinates y_1, y_2, etc., the result is, when $\frac{1}{3}h$ in numerator and denominator are cancelled, that

$$n = \frac{(y_1{}^2 + 4y_2{}^2 + 2y_3{}^2 + 4y_4{}^2 + y_5{}^2)}{(y_1 + 4y_2 + 2y_3 + 4y_4 + y_5) \times 2}.$$

Horizontal Position of Centres. If instead of the distance of the centre of gravity from AC the distance from a vertical line through A is required, then the former method of finding the moment of the area ABC is inconvenient, and the following is adopted, whereby the measurements of the ordinates used for determining the area and the moment about AC may also be employed in calculating the moment about AO. The moment of the little strips of area BD about AO is equal to its area multiplied by its distance from AO, or, say, $y \times b \times x$. This may be written $(y \times x) \times b$, which is similar to the previous expression for the moment about AC, except that the product of y and x is substituted for $\frac{1}{2}y^2$. As before, the total moment of the area ABC will be the sum of the moments of the little strips. Instead of writing down the square of the ordinate, we might write down the products of y and x for each of the ordinates selected. It will, however, be observed that the distances of the ordinates from AO are multiples of the common interval. For five ordinates, Nos. 1, 2, 3, 4, and 5, as shown in **141**, they are 0h, 2h, 3h, and 4h, respectively. As all the ordinates have thus to be multiplied by h, the common interval, it saves labour to wait with this multiplication until after the summation, in the same way as the dividing by 2 was left until the end in the previous estimate. The multiplication by the factors 0, 1, 2, 3, and 4 cannot, however, be avoided. The procedure is, therefore, to write down the ordinates y_1, y_2, y_3, etc., multiplying them by 0, 1, 2, etc., and again by 1, 4, 2, 4, 1. Adding together these products, and multiplying by $\frac{1}{3}h$, and by h, as that was omitted before, the result is the moment of the area about OA.

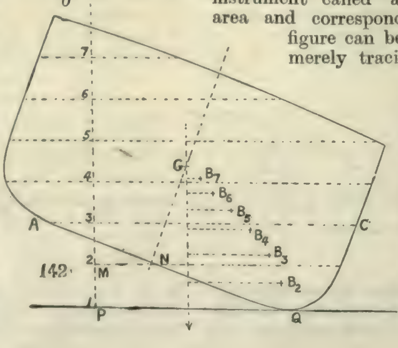
The horizontal distance of the centre of gravity from AO is therefore

$$q = \frac{(0 + 4y_2 + 4y_3 + 12y_4 + 4y_5)\,h}{(y_1 + 4y_2 + 2y_3 + 4y_4 + y_5)}$$

The distance of the centre of gravity of the area being known from two lines at right angles to each other, its position is completely determined.

The Centre of Buoyancy. When the moment of volumes have to be estimated, it is done by first calculating the moments of a series of parallel planes and then summing these moments up by means of Simpson's rule. The process is entirely analogous to the determination of moments of areas by first calculating the moments of the ordinates and then summing up these by means of Simpson's rule. We are now in a position to calculate the centre of pressure or centre of buoyancy. Let **142** represent a vessel somewhat inclined in the water and floating at the No. 3 water-line. The centre of buoyancy corresponding to this water-line is the centre of gravity of the immersed volume. The position of this point in a horizontal direction is determined by estimating the volume and the moment about any vertical line, say OM. The horizontal moment of the volume is the sum of the moments of the water-line areas. A series of horizontal equidistant planes are therefore drawn, as indicated, and in such a way that the bottom one passes through Q, the lowest point of the vessel. The area of the lowest plane will be zero, and the moment is therefore also zero. In the case of the other water-line planes, it is necessary to estimate separately the moments of the parts on each side of the reference line OM, and to deduct the moment of the one from that of the other, in order to obtain the moment of the entire plane. In the case of the water-line NL, it is also necessary to estimate the moment in two parts, as the reference line falls outside the plane. The moment of each of the parts of the water planes are estimated, as in the case shown in **141**, when the moment is required about the line AC. It is not necessary actually to draw the planes, because all the measurements for the ordinates can be made on the body plan of displacement sections after drawing the lines of the water planes in the required positions.

Moments of Buoyancy. When the moments of the second and third planes have been determined in this way, the first one being zero, they are put through Simpson's rule, the products added up and multiplied by one-third the distance between the planes. The result is the moment of the volume of displacement up to the water-line AC. While determining the moments of the planes their areas are likewise calculated, and afterwards they are also put through Simpson's rule, so that the volume as well as the moment is determined up to the required water-line. When both these quantities have been estimated, the latter divided by the former gives the distance that the centre of buoyancy is from the line OM. It will be clear that a water-line might have been chosen at any height and the moment and volume estimated in the same manner by dividing the volume up by any suitable number of equidistant planes. It is, however, convenient to divide nearly the entire volume by such equidistant planes and then to estimate the volumes and moments corresponding to each by adopting the same method as when the displacement was estimated at various drafts. The moments and volumes being determined, the position of the centre of buoyancy can be found for each of the water-lines. These points B_1, B_2, etc., corresponding to water-lines 1, 2, etc., are shown in **142**. Let the centre of gravity of the entire ship be at G. It will then be seen that wherever the centre of buoyancy falls to the right of the vertical through G, there will be an upward pressure tending to force the vessel back to the normal or upright position; in other words, the ship will be stable under those conditions. On the other hand, if the centre of buoyancy falls to the left of the vertical through G there will be a moment which will capsize the vessel. Let the angle of inclination of the vessel from the upright be 20° for the vessel indicated in **142**.



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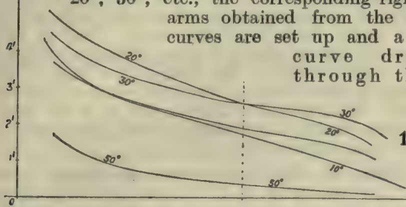
Cross Curves of Stability. The stability or instability of the vessel when at this inclination may be conveniently shown by a curve, such as the one marked 20° at **143**. The displacements, as calculated to the respective water planes, are here set off horizontally, and the distances between the vertical lines through the corresponding centres of buoyancy and the line through centre of gravity of the vessel are set off vertically. The curve marked 20° will thus, at a glance, show whether the vessel is stable or unstable at that inclination at any given displacement by the curve being above or below the base line. Similar calculations might be made for the vessel at other inclinations, say at 10°, 30°, 40°, etc., and the corresponding curves may be drawn as shown in **143**. Such a set of curves, called *cross curves*, represents the stability of the vessel at all displacements for those particular inclinations. The distances between the centres of buoyancy and the vertical through the centre of gravity are called the *righting arms*, because, when the vessel is stable, then these distances multiplied by the displacement represent the moment tending to right the vessel when she has been inclined. Wherever the cross curves of stability [**143**] fall above the base line there is a positive righting arm and the vessel is stable, but when the curves fall below this line the righting arm is negative and the vessel is unstable. Such a system of cross curves gives a complete picture of the stability of a ship, but it takes a considerable amount of time and labour to produce them as described above. They are, therefore, now always estimated by the aid of an instrument called an *integrator*, on which the area and corresponding moment of any plane figure can be read off simultaneously after merely tracing its outline by a pointer. When an integrator is employed it is applied to the cross sections, and the fore-and-aft summation of the areas and moments thus determined is done by Simpson's rule.

Ordinary Curves of Stability. It is often desirable to have a continuous representation of the stability of the vessel at various inclinations at a given displacement. This is easily

obtained from the cross curves by merely drawing a vertical line at the displacement in question [**143**], and then laying down a base line as in **144**, representing the degrees of inclination. At 10°, 20°, 30°, etc., the corresponding righting arms obtained from the cross curves are set up and a fair curve drawn through their



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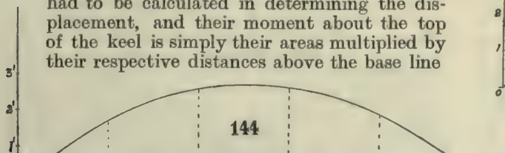
heads. This will give the exact righting arm at any inclination, the displacement remaining constant, and it is called a *curve cf stability.* Here, again, the vessel is stable where the curve falls above and unstable where it falls below the base line. At zero inclination a vessel must be stable or she will not remain upright. As she is being inclined a little the righting arm increases directly as the inclination. For somewhat larger inclinations it increases less rapidly, and eventually attains a maximum, after which it is reduced until it may possibly become negative. The maximum righting arm is, as a rule, only a few feet in length. The angle at which the righting arm becomes negative, and the ship therefore unstable, varies much, the average being about 80°. In many instances it is sufficient to know what the righting arms will be for the small inclinations, or what the rate of increase is as inclination begins. If this rate is, say, m feet per degree of inclination, then the righting arm at 2° inclination will be $2m$, and at 3° $3m$. It so happens that this rate of increase in the righting arm can be easily determined without producing the curve itself. In the upright position there is no righting arm as the two sides of the vessel are symmetrical. The vertical through the centre of gravity passes, therefore, always through the centre of buoyancy in that case, but the latter point will move vertically as the draft and displacement increases.

Vertical Position of Centre of Buoyancy. The vertical position of a centre of buoyancy in the upright condition of the vessel may conveniently be determined at the time the displacement calculations are made. The required centres of buoyancy are the height above the base line of the centres of volumes of displacement. This, again, is determined by estimating the moment of the water-line areas above the base line at the top of the keel. These areas, it will be remembered, had to be calculated in determining the displacement, and their moment about the top of the keel is simply their areas multiplied by their respective distances above the base line



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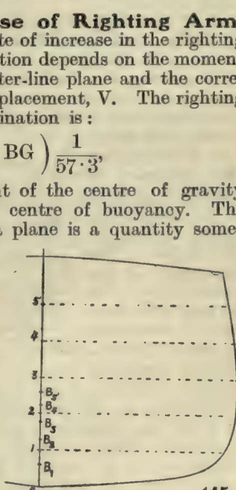
These moments may be put through Simpson's rule at the same time as the areas, and the moment and volume estimated up to each water-line. The former divided by the latter gives the corresponding heights of the respective centres of buoyancy above the base line. Figure **145** shows the centres of buoyancy, B_1, B_2, B_3, etc., corresponding to the water-lines 1, 2, 3, etc., respectively. It is, however, more convenient to record these heights in the same manner as the displacement and tons per inch immersion. The drafts are then set off vertically as in **146**, and the heights of centres of buoyancy horizontally.

Rate of Increase of Righting Arm. It is found that the rate of increase in the righting arm in the upright position depends on the moment of inertia, I, of the water-line plane and the corresponding volume of displacement, V. The righting arm per degree of inclination is:

$$\left(\frac{I}{V} - BG\right)\frac{1}{57 \cdot 3},$$

where BG is the height of the centre of gravity of the ship above the centre of buoyancy. The moment of inertia of a plane is a quantity somewhat similar in nature to its moment. The moment of inertia of the one side of a water-line plane is estimated by simply using one-third of the ordinates cubed in lieu of the ordinates employed in determining the area. If these ordinates are y_1, y_2, y_3, etc., the common interval h, then the



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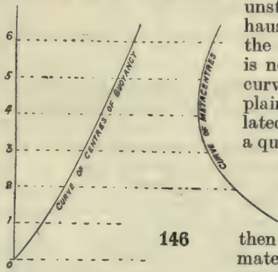
moment of inertia of the entire area, being twice that of one side, is:

$$I = \left(y_1^3 + 4y_2^3 + 2y_3^3 + 4y_4^3 + \text{etc.}\right)\frac{h}{3} \times \frac{2}{3}$$

The volume of displacement, V, and the position of the centre of gravity being known, the righting arm per degree of inclination may be determined. This quantity, it will be seen, is positive when $\frac{I}{V}$ is larger than BG, in which case the vessel is stable. When $\frac{I}{V}$ is less than BG, then the righting arm per degree of inclination is negative, or, in other words, it is an upsetting arm, and the vessel is unstable. If an exhaustive inquiry into the stability of a ship is necessary, the cross curves previously explained must be calculated; but if it is only a question of determining whether or not the vessel will float in the upright position, then the above estimate of the righting arm per degree of inclination is sufficient.



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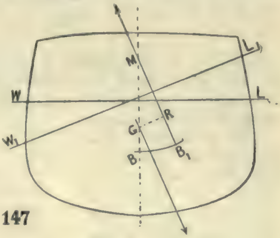
The Metacentre. It is usual to consider the conditions governing the stability of a vessel in the upright position from a geometrical point of view. Let **147** represent a vessel in an inclined position. The centre of buoyancy in the upright position, B, corresponds to the water-line WL.

When the vessel is inclined a little to the right the water-line moves to W_1L_1, and the centre of buoyancy to B_1. The new vertical through this point will intersect the original vertical line through

B in a point M. It is found that BM is equal to $\frac{I}{V}$. GM is therefore equal to BM – BG or $\frac{I}{V}$ – BG, and the righting arm per degree of inclination is $\frac{GM}{57 \cdot 3}$. The point M is called the *metacentre*, and it will be seen that the vessel is stable in the upright condition when G is below M, and unstable when G is above M, because in the former case the centre of buoyancy, B_1, is to the right of the centre of gravity G, when the upward pressure tends to bring the vessel back to the upright position, and in the latter instance it is to the left when the tendency of the water pressure is to incline the vessel further to the right. The metacentre is the centre of the curve in which the centre of buoyancy moves as the vessel is inclined,



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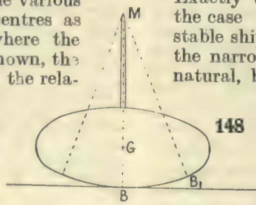
and it will again be seen that the condition for equilibrium is just the same in the case of ships as in the case of bodies on land—namely, the centre of gravity must for stable equilibrium be above the centre of the curve in which the point of support moves. It was seen that the height of the metacentre above B was equal to the moment of inertia of the water-line plane divided by the volume of displacement. For each draft or position of a water plane there is a displacement, a centre of buoyancy, and a metacentre. It is, therefore, possible to calculate the height of the metacentres above the centres of buoyancy for the various drafts and construct a curve of metacentres as shown in **146**. In most instances where the general character of a ship's form is known, the question of stability is decided only by the relative position of the metacentre and centre of gravity of the ship. The distance GM between these points is called the *metacentric height*. The larger the angle of inclination becomes, the less satisfactory is, however, the expression $\frac{GM}{57 \cdot 3}$ as a correct measure of the stability of the vessel.

Centre of Gravity of Ships. The metacentre is comparatively easily estimated, but, as already stated, the direct calculation of the centre of gravity is a laborious task, which is rarely undertaken. This point is easily determined when a ship is floating in the water by an experiment consisting in her being slightly inclined by a known amount of weight being placed at one side—in fact, the stability is measured directly. In a ship being designed the centre of gravity is estimated to be at the same relative height above the top of the keel as in other similar vessels, where its position has been exactly determined by experiment. Say, for instance, it has been found in the latter case to be 73 per cent. of the depth of the vessel above the top of the keel, it will then also be 73 per cent. of the depth above the keel in the designed vessel, and its position can be easily determined. If there are many heavy weights high up in a ship it will, of course, raise the centre of gravity, and, on the other hand, the placing of weights low down in the vessel lowers the centre of gravity or increases the stability. The height of the metacentre, depending as it does on the half-breadths cubed will be augmented very rapidly with an increase in the breadth of the vessel. This is the reason for the great importance of breadth in giving a vessel stability. In designing a ship it is difficult to adjust the position of the centre of gravity to suit the required stability, but it is an easy matter to modify the breadth at the water-line to bring about the desired result.

Effect of Stability on Rolling. It might be supposed that, as the stability of a vessel is so very necessary, it is also desirable to obtain as much as possible of it by making the metacentric height as large as possible. This is, however, not the case. In small boats and sailing vessels this height is some three to four feet, and in a cargo steamer it may be about the same, but in passenger steamers it may be less than one foot. The reason for the small amount of stability is the fact that high metacentres seriously affect the vessel's behaviour in other ways. Let **148** and **149** represent sections of two bodies resting on a plane support. As has already been seen, the first of the two will be the more stable, the radius BM of the arc of the points of support being the greater. If small logs of wood were cut to these shapes and laid on a table, it would therefore be found that greater force would be necessary to incline the one with the flatter section than the one of a more nearly circular form. If the two logs are set rocking on the table, it will also be found that the broad one will rock very violently or quickly. while the deeper one will move slower and more easily. Exactly the same effect will be experienced in the case of floating bodies. The broad or very stable ship will rock or roll more violently than the narrow and less stable one. This is quite natural, but it is a fact which has often been better realised by those who sail the ships than by those who have built them. It will be readily understood that an easy rolling motion is a very essential quality in a good ship, particularly one intended to carry passengers. The metacentre is therefore brought as low as possible by making the vessel as narrow as is consistent with safety. It is found that in a large steamer a metacentric height of only about 8 in. is sufficient, provided the vessel is stable at the larger angles of inclination, say up to 70° or 80°. In sailing ships it is necessary to have a fair amount of stability to keep them upright against the force of the wind acting on the sails.



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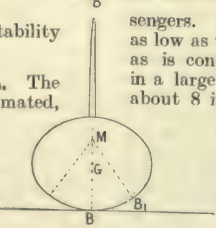

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The pressure of the wind tends to steady the vessel, so that the greater amount of stability does not seriously affect the rolling motion in this instance. The stability and the rolling motion of a ship are determined as above described, assuming her to float in smooth water. It might be imagined that what holds good under these conditions might not do so when the vessel is in the open ocean subject to the action of wind and waves.

It is, however, found by experience that a ship has sufficient stability at sea when she is found to have this in smooth water, and also that she will roll more or less at sea in accordance with the conditions governing her motion in undisturbed water.

Continued

THE GREAT SLAVE WAR

The Irish Rebellion. The United States and the Slave Trade Controversy. Abraham Lincoln. The War. Cuba and the Philippines

Continued from page 5846

By JUSTIN McCARTHY

The Irish Rebellion. The history of Ireland, as we have already said, had for long been closely associated with that of England, but the American Revolution brought the discontent that had long been felt in the country to a crisis. Molyneux, and immediately after him Swift, were among the few, not Catholics nor Irish by race, who understood the causes of Irish discontent. Among the English statesmen of the Georgian era Lord Chesterfield, who was appointed Viceroy in 1745, was practically the only one who saw to what the system of government which prevailed in Ireland was likely to lead, and he soon won the confidence and admiration of the Irish people.

The improvements he made in the government of Ireland, however, only shortened his term of rule. Influence was probably brought to bear on the King, and Chesterfield was recalled. He left Dublin surrounded by enthusiastic admirers, who besought him to return. On his recall, the discontent became greater than ever, and the new Patriot Party was started with Charles Lucas, a Dublin man, as leader.

Henry Flood succeeded Lucas, and when, by accepting office under the Government, he became unpopular, Henry Grattan, one of the greatest orators of all time, became leader in his place. A movement now began in Ireland for the formation of a Volunteer army. It had a great success all over the country, and soon 60,000 men were under arms, with Lord Charlemont as Commander-in-Chief.

Grattan and the Catholics. The Irish Parliament of those days was not a representative Parliament, for no Catholic could either be a member of it or even vote for the election of a member to it. Grattan succeeded in having some of these disabilities removed, and in the reformed Parliament, known as Grattan's Parliament, Catholics were allowed to vote for the election of members, though as yet no Catholic was allowed to have a seat in either House.

This Parliament resisted Grattan's further reforms, and Grattan himself became unpopular in the country because, as a result of his policy, the Volunteers were disbanded and dispersed. In 1794 a new Viceroy was sent to Ireland, Lord Fitzwilliam, a man of enlightened views, who recognised the justice of emancipation, and encouraged the efforts of the Irish leaders. For obvious reasons he was suddenly recalled, and another Viceroy appointed. This was a deathblow to the constitutional agitation of Grattan, and the success of the French Revolution encouraged Irish hopes for freedom. Ireland hoped for help from France, which was always regarded as the friend of Ireland. Shortly before this the club of "United Irishmen" had been founded by Hamilton Rowan, with Theobald Wolfe Tone, for a time, as secretary. Lord Edward Fitzgerald, who had been a member of the Irish Parliament, and a supporter of Grattan, and was, like Hamilton Rowan and Wolfe Tone, a Protestant, joined the United Irishmen when they began to organise rebellion.

An Appeal to Napoleon. Theobald Wolfe Tone went to France for the purpose of persuading Napoleon to send a fleet and a competent commander to assist in the rebellion in Ireland. He succeeded in his object, and as he had before this obtained a commission in the French Army, he was himself on board one of the vessels, which were unable to reach the land because of stress of weather. The expedition was, therefore, a failure, and Tone was captured with a number of French officers. He was tried by court-martial in Dublin, found guilty, and condemned to be hanged. He asked to be shot instead, but as this was refused, he committed suicide to escape the disgrace of the gallows. Lord Edward Fitzgerald was dead. He had been captured in Dublin after an unsuccessful rising in Ireland, and died in prison of a wound received from one of his captors.

It was now determined by the English Government that Ireland should be united with England by one Parliament, and, in spite of the protests of Grattan, the Act of Union was passed by a majority of sixty in the Irish Parliament, a majority secured by bribery and corruption. It became law on January 1st, 1801. Robert Emmet, brother of Thomas Addis Emmet, one of the leaders in the rebellion of "Ninety-eight," sacrificed his life in the unsuccessful rebellion of 1803. He was captured, condemned to death, and executed on the morning after his conviction.

The Presidency of John Adams. At the time of the death of Washington, John Adams was President of America. His life was almost co-equal with the reigns of the last three Georges. He had been a subject of George II., had rebelled against George III., and, an old man in the reign of George IV., he had been for years the free subject of a free Republic. Like Washington, he had a respect for established forms; in his days men still wore the habit of the eighteenth century, and the influence of the Old World was still strong.

Adams, like Washington, believed in a governing class whose place was at the head of affairs—like Hamilton, he distrusted the masses. There were already two parties in the State—Hamilton and Adams were rivals for the leadership of the Federalists, who believed in the Constitution and

wished things to remain as they were. Thomas Jefferson, the writer of the Declaration of Independence, was the leader of the Republican party, afterwards called the Democrats. He believed in the doctrines of the French Revolution and disliked England, whereas the Federalists were supposed to have a leaning towards English forms of government.

Naval War with France. The presidency of Adams was stormy; he made himself unpopular by introducing the Alien and Sedition Acts. The success of his administration was the naval war with the French Directory, in which the United States got the better of it. The war was caused by the attempt to extort fifty thousand pounds for the benefit of the Directory from the envoys sent by Adams to France. When Adams' presidency came to an end, in 1801, he was not re-elected. Jefferson was chosen in his place, with his colleague, Aaron Burr, as Vice-President.

With the presidency of Jefferson a new era began for the Republic; pomp and formality disappeared from official life. He was twice elected President, and the eight years of his office are important in the history of the United States. In them occurred the purchase of Louisiana from Napoleon, who had taken it from Spain, and a law was passed forbidding the importation of slaves after 1807. The American Navy had many successful struggles with the Barbary pirates, and Robert Fulton's steamboat was launched on the Hudson. Ohio was admitted into the Union as the seventeenth State. There had long been a dispute as to the ownership of the Ohio valley, but the larger part of it was at last made over to the Government and became known as the North-West Settlement. Eventually it became a State and took the name of its fair river.

A Famous Duel. One of the memorable events of Jefferson's presidency was the duel between Hamilton and Aaron Burr, who had long been rivals, and when, in 1804, Burr failed to secure the appointment as Governor of New York State, he attributed his failure to Hamilton. Hamilton was mortally wounded and died thirty hours after, mourned by the whole country. After this, public life was ended for Burr.

Jefferson's second term of office was now at an end. He would certainly have been elected for a third term if he had so desired, but he did not, and in 1809 he was followed by James Madison, of Virginia, one of the writers of the famous "Federalist" papers. He became a Republican Democrat leader, and as such was elected President when he was fifty-eight years old.

The war of 1812 cannot be looked back to with satisfaction by either side. America had much to complain of both from England and France, for Napoleon's decrees were as opposed to American interests as the claim of England to right of search. America had a kindly feeling for France, who had helped her to gain her freedom, and for England a feeling of dislike. A powerful party in the States was eager for war, the leader of which was Henry Clay, a young Virginian who had settled in Kentucky, had prospered at the Bar, had been in the Senate and the House of Representatives, of which he had been Speaker, and had advocated the partial abolition of negro slavery.

Clay's "Warhawks." Clay's party went by the name of the "Warhawks," and did much to stimulate the war spirit. England claimed the right to stop all American ships and to search them for English seamen. England insisted on her rights, stopped many American vessels, and carried off many English subjects, and many men who were actually Americans were also forcibly carried off. Thus thousands of native-born Americans were, in 1812, serving against their will in English warships. A commercial question was also involved. England issued orders forbidding the United States to trade with France, and America retaliated by an embargo forbidding any American vessel to leave port. The American merchants were not pleased with this interference with trade; and the fact that President Madison dressed in clothes entirely of American manufacture, to show that the country was independent of foreign produce, did not console them. The majority in the North were against war, but the influence of Clay and his Warhawks prevailed, and relations with England became daily more strained. Mr. Erskine, the British Envoy, was recalled when he made concessions. His concessions were repudiated, and another envoy, whose policy was more hostile, was sent in his place, but was also recalled.

The War of 1812. The war spirit grew rapidly. The office of a Baltimore editor who opposed the war was attacked by a mob and was defended by him, assisted by Generals Lee and Lingan, and at last they had to be lodged in prison for safety. But the mob attacked the prison and killed Lingan and so injured Lee that he never recovered. War with England was now declared, and some were anxious to declare war on France also. The United States were at a disadvantage, for although England was then at war with France, her naval power was enormous. Her Navy was the largest in the world, and that of America the smallest. She had experience only of small wars, in which, however, she had done well. The American Navy had the advantage that its sailors served of their free will, while many of the English sailors were pressed into the service.

At sea the war was on the whole successful for America, but on land she had only one success, and the conquest of Canada was not accomplished. The followers of the Indian Tecumseh took the side of England. General Hull, an American, had to retreat to Detroit after an unsuccessful attempt to invade Canada; another American force who surrendered to the English at the River Raisin was massacred by England's Indian allies. In August, 1814, an English army, under Admiral Cockburn, landed in Maryland and marched to Washington, which they entered, and by his order, and that of General Ross who served with him, the public buildings, including the President's house, the Capitol, the arsenal, and the offices of the State Department, were burned and the public

libraries destroyed—a deed which it is impossible to defend.

In January, 1815, General Sir Edward Packenham marched on New Orleans with about ten thousand men, Jackson defending the place with half the number. The English were defeated, and General Packenham killed. This was the end of the war. At Ghent at the time this battle was being fought a treaty of peace had actually been signed. No attempt was made afterwards to impose the right of search on American ships.

At the end of the war, James Monroe succeeded Madison as President. He had much diplomatic experience both in London and Paris. The Holy Alliance, established by some of the European sovereigns in 1823 for mutual aid, restored the King of Spain to his throne. The King asked for the aid of the Alliance to recover his possessions in South America and Mexico. This would have threatened both American and English interests, and Canning, who was then Minister for Foreign Affairs, suggested to the American Envoy that England and America should combine against the action of the Holy Alliance; but Monroe wanted America to meet the difficulty unaided.

The Monroe Doctrine. The policy of the Monroe Doctrine was an enlargement of Washington's policy of neutrality, and the words were John Quincy Adams's which declared that the United States could not view interference with the affairs of existing States by European Powers in any other light than as the manifestation of an unfriendly disposition towards the United States. Monroe accepted the responsibility for this, and the doctrine is therefore associated with his name.

Monroe was succeeded by John Quincy Adams, who was followed, in 1829, by Andrew Jackson, the last of the Presidents who had fought in the Revolution. His financial policy was not successful, and was the cause of the commercial crash which occurred in the first year of the presidency of Martin Van Buren, who succeeded him. Van Buren was not popular, and General Harrison, who opposed him for the presidency, was successful, and became the ninth President. But he died in a few weeks, and was succeeded by his Vice-President, John Tyler. During his presidency the dispute with England regarding the boundary between Canada and the United States was settled by the Ashburton Treaty, arranged by Lord Ashburton and Daniel Webster.

During the presidency of James Knox Polk occurred the war with Mexico and the settlement of the dispute with England concerning the ownership of Oregon.

The Fugitive Slave Law. The twelfth President was General Zachary Taylor, a well-known soldier, who died after two years, and was succeeded by his Vice-President, Millard Fillmore, during whose presidency the famous "Fugitive Slave Law" was passed.

The question of negro slavery had at the time of the Convention and the forming of the Constitution been a difficulty which had been met by compromise, those who were opposed hoping that the necessity for it would soon cease; but the invention of the cotton gin by Eli Whitney, which made cotton the chief produce of the South, caused a great demand for slave labour, and it also made the Southerners wish to increase their territory, as cotton exhausts the land it grows in, and demands new soil, to provide which the South was anxious to add new States to the Union. The men of the Northern States, being opposed to slavery in any form, did not wish it to increase, and it was agreed that there should be a non-slave State for every slave State to preserve the balance.

Frederick Douglas, a Maryland slave, who had educated himself, became convinced that he would no longer be a slave; he escaped to the North, and became one of the leaders of the Emancipation movement.

A Book that Made History. One of the greatest influences in the Anti-Slavery cause was Mrs. Harriet Beecher Stowe's famous novel "Uncle Tom's Cabin." It had an enormous success, was translated into every language, and read in every part of the world. It was vain for the Southerners to protest against the importance given to it; its effect was extraordinary, and made countless converts to the cause of Abolition.

The admission of California as a State was an important event in the controversy. California was a free State, and to balance its admission, and also the abolishment of slavery in the district of Colombia, the Fugitive Slave Law was passed, enabling owners of slaves to bring back those who had escaped and taken refuge in non-slavery States without trial by jury. The law was opposed by all the Abolitionists, but was carried notwithstanding. During the presidency of Franklin Pierce, the antagonism between the two parties increased, and the members went to the two Houses armed. Charles Sumner, the famous Abolitionist orator, was assaulted by a Southerner in the Senate, and for a time his life was in danger. It was now proposed to create new territories, and to allow them to decide whether they would be for or against slavery. This decision was strongly opposed by the North, but the South won the day. The most prominent of the Anti-Slavery men was John Brown, who fought with the armed men of the other side from Missouri and defeated them. During the term of the next President, James Buchanan, John Brown, his two sons, and twenty other men invaded Virginia at Harper's Ferry. He was met by 1,500 Militia, and his force was all either killed or disabled. One of his sons was killed, and he himself was wounded. He lived, however, long enough to be tried and hanged. The agitation was now at its height, and soon after Brown's death the presidency of Buchanan came to an end, and the new President was elected.

Abraham Lincoln and the Slave Trade. The election of Abraham Lincoln opened up a new era in the history of the American Republic. Lincoln was born in Kentucky in 1809, and was the son of an energetic farmer. He obtained only a limited education, but he made the most of it. He soon became drawn

into local politics, and was elected to the Legislature of the State in which he lived, continuing to rise in public estimation and becoming known as a resolute opponent of the slavery system. In 1860, he was adopted by the Republican party as their candidate for the Presidency, and in the March of the following year he was elected by a great majority over the opposing candidate. Lincoln at once proclaimed his adherence to his anti-slavery principles, a declaration which led to the outbreak of the Civil War.

The Beginning of the Struggle. The Southern States had always been given to military training and the use of arms, while in the Northern States agriculture, trade, and commerce mainly occupied the people. Lincoln took prompt steps to form an army with which to encounter the uprising South, but the Southern States, where a seceding movement had long been contemplated, were in much better condition than the North for a trial of arms when the strife came on. In the first battle of any consequence, that of Bull Run, on July 21st, 1861, the Northern forces were defeated, and had to make a hasty retreat to Washington. But as the war went on the Northern forces grew more and more efficient in the art of war, and won some splendid victories. Indeed, the commanders and the soldiers on both sides displayed the highest capacity for war; and if, on the side of the North there were generals such as Grant, Sherman, and Sheridan, there were on the other side men like Thomas Jonathan Jackson, and Robert Edward Lee.

The Confederates (the Southerners) had fixed their capital at Richmond, in Virginia, and elected Jefferson Davis as their President. Jefferson Davis had been educated at the military academy at West Point, had served in several frontier campaigns, and then entered political life and sat in the Senate for some years, where he distinguished himself as an advocate of the right of each State to maintain slavery if it would.

The war went on until the middle of May, 1865, when the Confederate States were compelled to give up the struggle. The victorious Federals (the Northern States) behaved with great magnanimity towards Jefferson Davis, their prisoner. He was imprisoned for the time and then released on giving security for his peaceful conduct in the future. The close of the war was followed in strange and sudden fashion by President Lincoln's death. On April 15th, 1865, he was attending a theatrical performance in Washington when he was shot by Wilkes Booth, an actor, who was to all appearance insane.

The Dispute over the Alabama. There was a serious controversy between Great Britain and the United States with regard to the steamer Alabama, a privateer employed during the war in the service of the Confederates, having been built in an English port by an English shipbuilding firm, and manned chiefly by English seamen. The United States Government made strong complaint concerning the injuries inflicted on the Federal mercantile shipping, and put in a claim for the repayment of those losses as well as for indirect losses caused by the transfer of trade from British to American shipping. This dispute went on for a considerable time and was settled by an International Conference held at Geneva in 1872, which rejected the indirect claims of the Federal Government but awarded heavy damages for the losses directly caused by the ship's expeditions.

After the death of Abraham Lincoln, Andrew Johnson, Vice-President, succeeded him, and was in his turn succeeded by General Grant. Then followed Rutherford Hayes, General Garfield, who was assassinated in 1881, General Arthur, Grover Cleveland, General Harrison, Grover Cleveland again, William McKinley, who was assassinated in 1901, and Theodore Roosevelt, who was a second time elected to the position of President and still holds the office.

War with Spain. One of the most remarkable events in the recent history of the United States was the war between the Republic and Spain. This war was brought about by the manner in which the Sovereigns of Spain had long governed Cuba and other islands in the seas which wash the southern coast of the American Republic. Spain had ruled those islands according to the systems universal among conquering states during the Middle Ages, and had not altered with the growth of modern civilisation. The result of this was that the inhabitants of the subjected islands were constantly breaking out into insurrection against the Spanish rulers, insurrections which were put down by unsparing force and remorseless cruelty. There were several expeditions from the United States in support of the Cubans, but as they had no support from the American Government, they did not succeed. But in spite of this it became apparent that the United States would have to take decided steps to bring about a better condition of things in Cuba.

The States Acquire Cuba and the Philippines. The President of the United States tried to do something through the influence of some of the European states. The Government of England was friendly towards this proposal, but other European Governments —France, Spain and Austria in particular—were more inclined to bring pressure to bear upon the United States to the end that Spain might be allowed to govern her islands in her own way; and so the project failed, and Spain became more arrogant in her defiance of the United States.

In the middle of the crisis a war steamer belonging to the United States was blown up in the harbour of Havannah, and although the Spanish insisted that the occurrence was accidental, war began. But it had no sooner begun than it was over.

The Treaty of Peace was signed at Paris on December 10th, 1898, and Cuba and the Philippines became part of the possessions of the great American Republic, from which they received absolute local freedom, with the full assurance that in the due course of time they were to receive national independence.

Continued

PRINCIPLES OF COMMERCIAL DESIGN

Group 8
DESIGN
2

Continued from page 5821

Repetition by Stencil. The Problems of Composition, Spacing and Proportion. The Necessity for Fitness in Means, Material and Purpose

By P. G. KONODY

A BEAUTIFUL form in Nature constantly repeats, but repeats always with a difference. While Nature is lavish and informal, design must be formal and restrained. The essence of the repeat in design is one of exact reduplication, which is contrary to Nature. The designer, therefore, will find that repeated ornament must be abstract in order to be satisfactory. He must start by building up his design on some geometrical basis—the square, the diamond, or the circle. Then let him think out his leading feature, some flower or graceful curve, which, by such principles as those of balance or contrast, will suggest other features ; but the final test of all must be the capacity to repeat. It must be remembered that all sorts of free scroll motives are consistent with, and, indeed, based upon, a geometrical ground-plan. Bold flowing pattern, with richness and variety of detail, is perfectly possible on a geometrical base ; whereas, without a geometric plan, want of balance, irregularity of lines, and awkward gaps are certain to occur, only to be perceived when a paper is hung. Above all, it is important that the designer should constantly test his repeat.

Stencil Design. One method of obtaining an exact repeat is to use a stencil pattern. By its means ornament may be duplicated economically without the aid of machinery, and it enables the artist not only to execute his own design, but to allow the personal element to enter into its application. The simplest form of stencil is that cut out with the knife on a piece of cartridge paper. Let the beginner try first the effect of cutting out a simple form—say, a star or a single flower. If the stencil is then placed over a sheet of paper, pigment may be rubbed or painted over it, and will leave the pattern registered on the ground. From this experiment it is but a step to the cutting of more complicated designs. In order that the stencil plate may hold together strongly, the pattern must be broken up into small parts, or held together by "ties." These ties are like the "brides" in a lace pattern, but in lace the design is complete in itself, and the ties serve simply to hold it together. In a stencil design the ties should form an integral part of the pattern. Perfect continuity of line is obviously impossible, and the designer must therefore find convenient ways of uniting his masses and crossing his lines so as to form natural ties. The Japanese have always excelled in the art of stencilling, and some of their flower patterns are marvels of dexterous craftsmanship. In many of their intricate patterns the ties consisted of fine human hair. One great advantage of the stencil is that in the personal application of the colour it allows the artist to use pleasing gradations of tone.

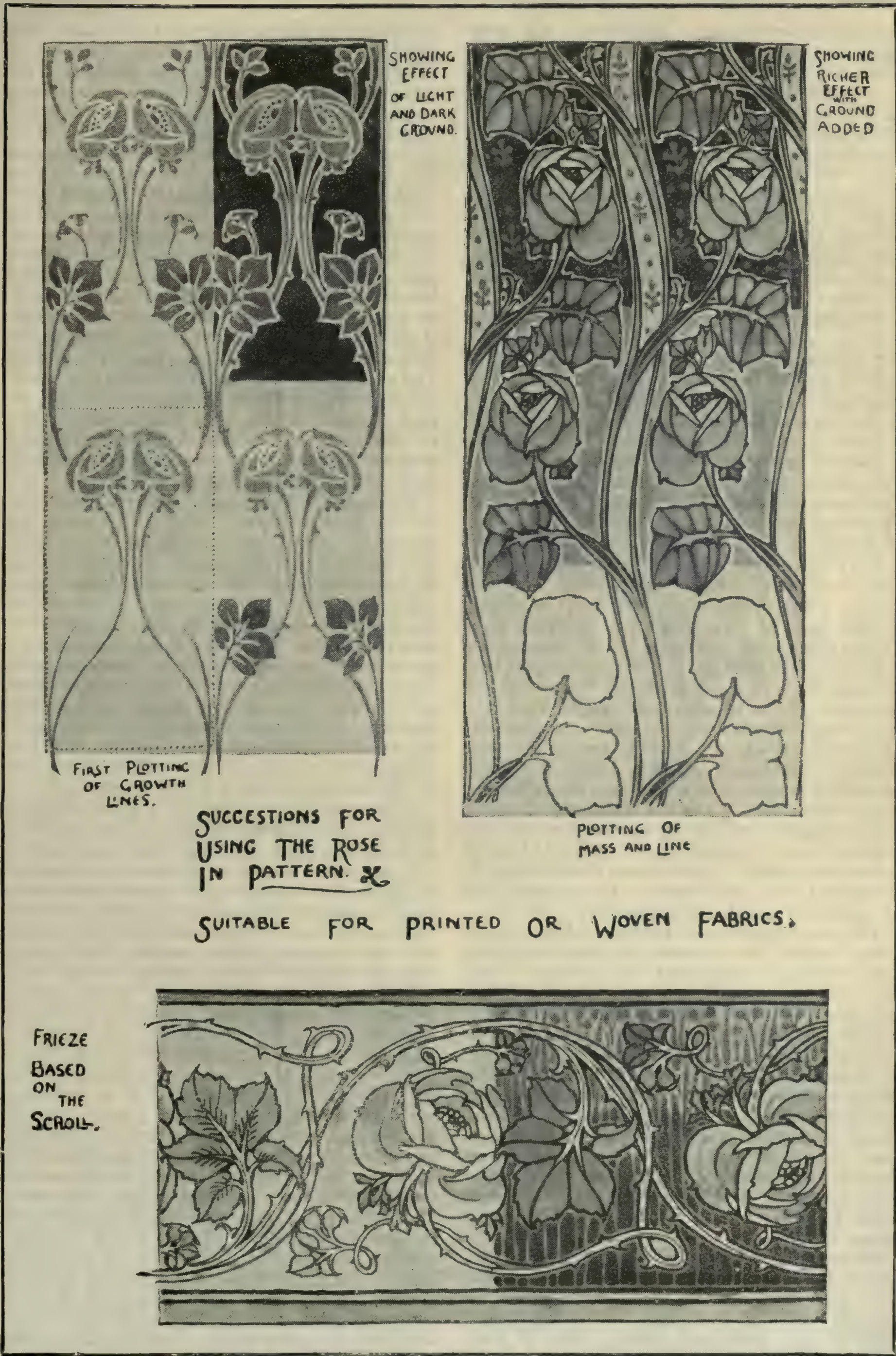
The Problem of Composition. The system of repeat is one by which units of ornament are distributed over large surfaces, such as wallpapers or carpets. Another problem that the designer has to solve is that of filling harmoniously a given space—a square or circle, a rectangular panel, a diamond, or lunette. This problem of filling a defined space, the problem of "composition," is one that presents itself to every painter. In his case he has to represent in a given space a piece of Nature that, as it were, composes itself ; or else he has to select and define in his given area certain aspects of the Nature before him. The designer, on the other hand, is called upon not merely to select and interpret Nature, but to produce original ornament for distribution over all kinds of spaces, amid varied surroundings, and for execution in different materials.

It is impossible to formulate any laws for composition, for it is absolutely free from all rules and must largely depend on natural taste. Common-sense should teach the student that a circle should not be filled in the same way as a square : and that, if a naturalistic composition is employed, a stiff-growing, formal flower, like the tiger-lily or the tulip, should not be used to fill a space enclosed by flowing or spiral lines.

The Mastery of Spacing and Proportion. The main principle of spacing is that all decoration should follow the structural idea, emphasising and enforcing the lines of the thing or space decorated. The principal lines and masses should harmonise with or repeat the outlines of the space. Where the human figure enters into any scheme of decoration, it is particularly necessary that it should be so adapted that its main lines and curves follow the form of the space which it fills. Among the greatest masters of spacing are the Japanese, whose work has had so much influence on modern European art. It is a common error to suppose that Japanese designs are merely haphazard and accidental. Careful study, however, will show that the principal and subsidiary masses are a matter of deliberate arrangement. A Japanese designer, moreover, never runs to riot in his ornament, but excels in the useful quality of leaving open spaces untouched in his design.

Taste and experience teach that certain spaces and proportions are harmonious, and others not ; but here, again, mathematical laws are impossible. In the perfect human figure the head bears a definite relation to the whole height ; and in the same way the relation between capital and column in classical architecture became a matter of

8. EXAMPLES OF THE ADAPTATION OF PLANT FORM TO DESIGN



9. FURTHER EXAMPLES OF THE ADAPTATION OF PLANT FORM TO DESIGN

definite measurement. Experience will soon show the value of certain proportions—that a panel, for instance, should be absolutely square, or else plainly oblong. In mounting a drawing or engraving, the eye demands that greater space should be left below than above ; for it is an optical fact that if the two spaces are actually equal the lower appears less than the upper. To make a room half frieze and half dado would be disastrous to decoration. It will thus be seen that equality is often antagonistic to good design. The Greek architect, for instance, never allowed two mouldings of the same width to come together on his frieze.

Fitness in Means. To all good design beauty, in conjunction with fitness, is essential. By fitness may be understood suitability in respect to the means by which the design is executed, to the material in which it is expressed, to the purpose for which it is intended, and the position which it is meant to occupy.

The designer should never attempt to conceal the means by which his work is produced. Pen or brush, hammer or chisel, each should be allowed to tell its own tale in its own language. Modelling in clay, to take an instance, should never be carried to such sharpness and crispness that it appears to have been worked with the chisel. Chip-carving, done with knife or chisel, should keep its own simplicity, differing at a glance from work produced by the gouge, the drill, and other tools. It follows, too, that the best designer of work to be produced by mechanical processes will be he who understands the capabilities and limitations of machinery, the methods by which carpets are woven and wallpapers printed. Machinery is, in a sense, the curse of modern design. There no longer exists the old joy of handicraft, when the artist was designer and craftsman too, letting hand and mind work together in the preparation of a thing of beauty for beauty's sake. At the same time it must be recognised that mechanism is an essential part of applied art, and must remain so.

The artist who would produce effective work must realise the existence of the industrial and economic conditions of to-day. The designer for wallpapers, for instance, must remember that the printer's block is twenty-one inches in size ; and he should know how the colour-printing is worked, and what number of printings are commercially possible. The designer of carpets must remember that carpet-weaving is done in square or diagonal lines, giving a pattern really by means of a succession of square tufts. He cannot therefore depend on delicate curves, but must allow for squareness in design ; but, on the other hand, he has practically no limitation in his colour scheme.

Fitness in Material. The designer must also be influenced by knowledge of his material, its colour and texture, its adaptability for cutting, weaving, moulding, or beating into a form at once useful and artistic. Iron or gold, glass or clay, will all require a different treatment and the use of different tools ; and these separate influences should all be apparent in the finished work. The natural qualities of the material should all be emphasised—transparency in glass, massiveness and solidity in stone and marble, strength and lightness in wood, and so on. To represent in marble all the delicate intricacies of a lace veil is ingenious, but not art. A glass window must never emulate the finished work of a painter on canvas ; its province is to be a mosaic of glowing colours, subordinate to the architecture of which it should form an obvious part. When the glassworker begins to attempt the full chiaroscuro of the painter on canvas he loses at once the individuality and beauty of his own art. Material and process should always determine the pattern and character of ornament. The potter's clay thrown on the revolving wheel, the molten glass blown by means of a tube, the plaited straw of the early basket-maker, seem to lend themselves to certain simple and natural designs. The best design is always that naturally suggested by the material itself [**8** and **9**].

Fitness in Purpose. Material must constantly enforce certain designs, as when the mediæval carver was compelled to compose his figures in curves to suit the twisted tusk. In material less simple and with designs more complicated, the material must be allowed to assert its own individuality. The designer must always be sure that the characteristics of a pattern are conformable to his material. He should visualise his work in its completed form, not looking at his design simply as a finished drawing upon paper, but always bearing in mind the aim and purpose of his work, the conditions under which it will be used, and the nature of the material in which it will be executed.

In textiles there should be a great difference between a pattern for hangings or a dress material, both of them meant to hang in folds, and that for a carpet, which lies flat with its pattern displayed. Wallpapers or carpets should possess characteristics quite distinct from a curtain or dress material. Wall and floor are stiff and uniform, while curtain and dress are flexible and uneven. To decorate both in precisely the same way would be to transgress the law of fitness. For a floor, a pattern of a rectilinear character will best express solidity and firmness, as is shown in tiles, mosaic, and parquetry work. The sense of flatness may be preserved in any formal pattern, not necessarily rectilinear, but it is interfered with by strongly contrasted colours, or by colours that give the appearance of more than one plane. A pattern, too, that might be suitable and beautiful in light silk would be ill-adapted to a heavy fabric ; and what might seem coarse and extravagant in muslin might be eminently suitable in a cretonne. Where a rich material, such as silk or velvet, is in question, its natural beauty and richness are best displayed by using a large pattern which leaves plenty of spaces to show the plain ground. For a cheap material, such as a common calico, a small and crowded pattern may be advisable.

Continued

NICKEL, LEAD, & ALUMINIUM

Occurrence and Metallurgy of Nickel, Cobalt, Lead, and Aluminium. Their Properties and Industrial Uses

Continued from page 5860

THE metals here dealt with are three of the most interesting. Two of them, nickel and aluminium, have had practical application, as metals, only in modern times, and are further peculiar from the fact that they are produced industrially by processes quite outside the range of general metallurgical practice. Again, two of them represent the limits of weight among commercial metals: lead is the heaviest and aluminium the lightest of the industrial metals.

NICKEL AND COBALT

In the early part of the eighteenth century there was an arsenious ore which much troubled Swedish and German miners, owing to its deceptive resemblance to native copper. They termed it *koppar-nickel* or *kupfernickel,* "devil's worthless copper," from a form of the German *nicklaus,* which is represented in English by "Nick," "Old Nick." Cronstedt examined it and in 1754 isolated the metal contained and, reasonably enough, called it nickel. The closely allied metal cobalt probably got its name in similar fashion from the German *kobold* (goblin) on account of its poisonous and troublesome mining character.

Properties. Nickel and cobalt are hard metals related, chemically, very closely to one another and to iron, belonging to the iron group of metals in the Periodic System of Newlands and Mendeléeff. They are nearly always found in association. Nickel (Ni, atomic weight, 58·77) is a white metal with a brilliant lustre which is but slightly tarnished by air, moist, dry, or carrying carbon dioxide, at the ordinary temperatures. Cobalt (Co, atomic weight generally given as 59, but uncertain; a value found in 1906 is 58·895) is a reddish-white metal which is untarnished in air. Both metals, when finely divided by reduction from their oxides with hydrogen, spontaneously ignite in air, and on both a scale of dark-coloured oxide is formed when strongly heated.

Nickel has a specific gravity of 8·35, increased by rolling to from 8·6 to 8·9, and cobalt one of 9·0. The specific heat of pure nickel is given by Roberts-Austen as 0·1108 and by Regnault as 0·1086, iron being 0·113 (Roberts-Austen). Its coefficient of linear expansion for 1° C. is 0·0000127 (Roberts-Austen), compared with 0·0000121 for iron. The melting point of nickel has been variously determined at from 1,390° C. to 1,500° C., while the fusing point of cast iron is from 1,135° C. to 1,220° C. (Roberts-Austen); pure, 1,600° C. (Hiorns). Cobalt is slightly more fusible than iron. When molten, nickel occludes carbon monoxide, which is given out on cooling, rendering the metal porous.

Nickel is a very hard but malleable and ductile metal, and has been rolled and hammered into sheets not more than 0·0008 in. thick, and drawn into wire not exceeding 0·004 in. in diameter. Its tensile strength has been said to exceed that of iron. St. Claire Deville found that a nickel wire containing 0·3 per cent. of silicon and 0·1 per cent. copper bore a strain of 200 lb., while a similar iron wire broke at 133 lb.; while Kollmann found that the tensile strength of a specimen of Westphalian nickel equalled that of medium hard Bessemer steel. The following results were obtained by Mr. R. A. Hadfield for 98·8 per cent. cast and forged nickel. The comparative values given for iron are by Professor Arnold for 99·8 per cent. cast and forged iron.

TENSILE STRENGTHS OF NICKEL

—	Elastic limit. Tons.		Tensile strength. Tons.		Elongation. Per cent.	
	Nickel.	Iron.	Nickel.	Iron.	Nickel.	Iron.
Cast (unannealed) ..	11	14	16·25	20	4·5	16
Forged (unannealed)	14	14	32·2	22	45·5	47
Forged (annealed) ..	7	—	31·25	—	54	—

With 98 per cent. cold rolled nickel Fremont (of Le Nickel Compagnie) obtained an elastic limit of 22 tons per square inch. The metal is easily welded at a white heat both with itself and to iron and to certain other metals; this property is the basis of an excellent nickel-plating process invented by Fleitmann.

Nickel is magnetic, though not equally with iron (1 : 1·5); cobalt is only slightly magnetic. Both metals are said to lose their magnetism when heated to about 350° C. Their relative electric conductivities (Ag = 100) are 12·89 and 16·9 respectively.

Nickel is slightly acted upon in the cold by hydrochloric and sulphuric acids, but dilute nitric acid and *aqua regia* dissolve it readily. It is, however, but very slightly attacked by organic acids and the alkalies. Fused alkalies oxidise platinum; and nickel, therefore, replaces this metal for laboratory crucibles and other vessels used for melting alkalies. Where expense is a secondary consideration it is a valuable metal for culinary utensils.

Nickel and Cobalt Ores. Nickel is comparatively a non-abundant element. It is present in the sun's atmosphere, and has been found in meteorites. It is very rarely found native. Its ores are complex mixtures, divisible into three classes: sulphides, silicate, and arseniferous. Cobalt ores are almost invariably associated with nickel ores, and cobalt frequently replaces nickel in part.

The most important mines are those of Sudbury, Ontario (sulphides), and of New Caledonia (silicate). Mines in different parts of Europe produce smaller quantities of arseniferous ores. Almost the whole of the 11,810 tons of nickel produced in 1904 came from the Sudbury and New Caledonian ores.

The largest deposit is probably that of the great nickeliferous district of Sudbury, covering about 2,800 square miles. Here the ore consists of a mixture of chalcopyrites ($Cu_2S.Fe_2S_3$) and pyrrhotite, a monosulphide of iron, part of the iron and copper in the two minerals, varying from 2½ per cent. to 10 per cent. (partly with the depth of the deposit), being replaced by nickel. This is a sufficiently large proportion to make the deposits pay as nickel ores, the copper (practically the whole produced in the province of Ontario) being a by-product. The ore is not found in veins but in irregular lenticular masses and pockets.

Millerite (NiS), a valuable source of nickel, is sometimes found with the Sudbury pyrites.

The ore of New Caledonia is *garnierite* [(NiMg) $SiO_3 + n\ H_2O$], a silicate containing from 7 per cent. to 8 per cent. of nickel, 41 per cent. to 46 per cent. of silica, and oxides of iron, aluminium, and magnesium, found by Garnier in 1875. It is free from arsenic, sulphur, and copper. Other nickel ores are the blende, glance, cobaltic pyrites, and kupfernickel, found in smaller quantities in various parts of Europe. Smaltine, cobaltine, and cobalt bloom are European arsenious cobalt ores.

Treatment of Ores. There are many nickel ore reduction processes, but the commercial and the important ones come under three heads: copper ores (chalcopyrites) by two processes only, the Mond and Orford; silicate ores (garnierite) by repeated reverberatory roastings; and arsenical and sulphurous ores by the production of a matte or speiss. In all processes nickel oxide is produced which is reduced to the metal.

The first process in treating the sulphurous ores of Sudbury is roasting. After crushing and sorting, the ore is roasted in heaps of from 600 tons to 1,800 tons, piled up on a bed of wood to about 6 ft. or 8 ft. high. The heaps are allowed to burn for from six to ten weeks, whereby the sulphur content is reduced from 22 per cent. to 7 per cent., the iron partly oxidised, and the ore disintegrated and reduced to a matte.

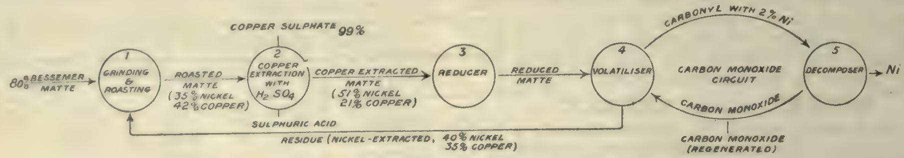
The silicate (New Caledonian) ores do not require the preliminary roasting. At first their purity induced their discoverer to work them direct in wind furnaces on the same principle as that by which pig-iron is produced. But this process has been abandoned because it was found impossible to remove sulphur entirely, and a matte is produced by smelting in a water-jacketed furnace with sulphur or salt-cake. This matte is powdered and roasted with quartz sand two or three times to reduce the percentage of iron. The nickel is then oxidised by double roasting in a reverberatory furnace (the iron and sulphur being driven off) and the oxide reduced by heating cubes of it, made with flour or other paste, in a muffle or crucible furnace.

Bessemer-refined nickel matte (containing 24 per cent. of sulphur, 75 per cent. of nickel, and about 0·5 per cent. of iron) cannot be further treated in the converter, partly because the nickel oxidises with the sulphur, and also because, with the reduction of the proportion of sulphur, the melt tends to solidify.

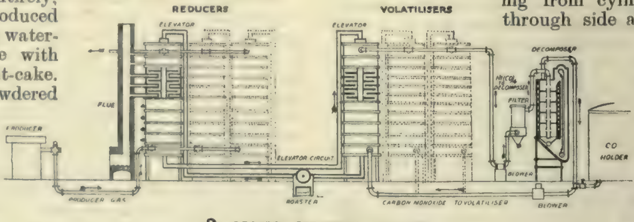
Sudbury matte contains copper, and the nickel can be extracted from it in the dry way only by the Mond and Orford processes.

The Mond Process. This is the only process in metallurgy where the metal sought forms a gaseous compound during the process of recovery. It depends upon the fact, accidentally discovered by Drs. Mond and Lange in 1889, that at about 50° C. nickel forms a volatile poisonous compound with carbon monoxide, known as *nickel carbonyl*, $Ni(CO)_4$, which is entirely dissociated by raising the temperature to 150° C. Iron is the only other metal which forms such a compound. Several patents were taken out, and the Mond process has been commercially operated since the beginning of 1902, at Clydach, near Swansea. The principal operations of the process are shown diagrammatically [1]. Cupriferous nickel ore mined at Sudbury is roasted and concentrated by Bessemerising, and the matte obtained, containing from 30 to 40 per cent. of nickel and about 45 per cent. of copper, is ground in ball mills at the works in South Wales, and calcined to form nickel oxide and drive off sulphur and arsenic. It is then leached with sulphuric acid, about half the copper being extracted as sulphate, which is crystallised out and sold. A diagrammatic representation of the plant used is given in 2. The copper-extracted matte, which is separated by filtration and centrifugalisation, is carefully reduced in reduction towers with water or producer gas. In order to prevent the formation, later on, of iron carbonyl, it is necessary at this stage to keep the temperature as low as possible, so that iron oxides may not be reduced. This regulation of temperature is achieved in the reducers, which are built up of a number of short cylinders, with hollow bottoms, through which combustion gases from a flue, or water, or air, may be circulated for heating or cooling. The water gas rises through the towers, passing over a stream of matte, descending from cylinder to cylinder, through side and central openings by means of stirrers, reducing the oxide to crude metal. The reduced nickel is conveyed by means of elevators to the volatilising towers, where carbon monoxide is passed over it in a similar manner to the reduction treatment. The volatilisers are similarly constructed of cylinders, without hollow bottoms, however, the heat of the material from the reduction towers and of the gas rising through being sufficient to maintain the temperature of 50° C. required for the formation of nickel carbonyl. The nickeliferous material circulates by means of elevators among the volatilisers for from seven to fifteen days, to complete the formation of carbonyl.

The nickel carbonyl gas is then drawn by means of a blower through a filter (to remove flue dust) into the decomposing tower. Here the gas passes over



1. DIAGRAM OF OPERATIONS OF MOND NICKEL PROCESS



2. MOND NICKEL PLANT

granules of metallic nickel, kept in motion to prevent cohesion, at a temperature of about 200° C., by means of which it is broken up into nickel and carbon monoxide, the metal being deposited on the granules, and the gas released and returned to the volatiliser. The reaction is shown by the equation $Ni(CO)_4 = Ni + 4CO$. The granules are essential to start the decomposition. The pellets produced are particularly suitable for alloying. They contain from 99·4 to 99·8 per cent. of nickel, never more than 0·5 per cent. iron, and traces of sulphur and carbon.

The process is somewhat delicate, owing to the temperature conditions which have to be observed; but, from the fact that nowhere does it exceed 300° C., the fuel consumed is small in amount, and the repairs to the plant inconsiderable. It is automatic and also regenerative so far as the carbon monoxide is concerned. Sir James Dewar took out a patent in 1902 by means of which the process of carbonyl formation is considerably shortened.

The Orford Process and Speiss Extraction. In the Orford, or separation-smelting process, a nickel-copper matte is smelted with salt-cake and coke, producing "tops" and "bottoms," which are re-smelted. The nickeliferous sulphide bottoms obtained are roasted with salt in a reverberatory furnace, nickel oxide being formed. This is leached out and reduced with coke in the furnace to crude metal. Until 1903 the nickel so produced was electrolytically refined, but as nearly half the charge became anode scrap in the process, it had to be abandoned when metal over 99 per cent. pure was produced by the carbon-reduction and Mond processes.

Nickel speiss is produced from arseniferous ores, or, with matte, from a cupro-arseniferous ore, by oxidation with silica. The metals pass in a regular order into the slag as silicates, cobalt and nickel going last. Unoxidised arsenides form a speiss, which sinks through the slag. When only a nickel and cobalt speiss remains, this is re-fluxed and re-fused to obtain a nickel speiss with a cobalt slag. The speiss may then be worked up by roasting, or, if a particularly pure nickel is required, by the complicated wet process consisting of a series of about sixteen precipitations and other chemical operations.

Electro-chemical Treatment. No known ore of nickel is pure enough or contains enough nickel to be directly electro-chemically treated. Electrolysis is not at present practically applicable to nickel mattes. High potentials are necessary to deposit nickel from solution, and these cause most other metals to be co-deposited. A thick deposit of nickel is therefore very difficult to obtain, although there is nothing lacking in the thin coating obtained in nickel-plating. Electrolytic refining of nickel and cobalt is also impracticable, but a copper-nickel alloy is produced by an electrolytic process from mattes.

Refining. Formerly coarse nickel contained as much as from 10 to 40 per cent. of impurities, but metal 98 per cent. pure is now readily obtained from any ore, while Mond nickel is from 99·4 to 99·8 per cent. pure. The chief impurities are iron (1 per cent destroys extensibility in German silver); sulphur and arsenic (1·1 per cent. of either renders nickel unsuitable for rolling); nickel oxide (0·3 per cent. makes it brittle); and chlorine (0·18 per cent. makes German silver unrollable). Cobalt, copper, and silicon in small quantities do not injure nickel. The absence of these impurities is aimed at by making as pure a nickel oxide in the preliminary processes as possible. Fleitmann found that magnesium effectively removes these small amounts of impurities, which at first prejudiced the use of nickel in alloys. It was added as a nickel alloy in amounts less than ⅛ per cent. Aluminium has now entirely superseded magnesium for this and similar purposes.

Nickel Alloys. The largest use for nickel is in its alloys, German silver and nickel-steel. On account of its non-tarnishing properties and power of taking a high polish, it is very largely used to coat other metals.

Nickel-brass alloys are harder, stronger, and more chemically resistant than brass, while nickel-steel alloys are harder, tougher, and more tenacious and ductile than steel; but they are somewhat delicate mixtures, and are affected by very small quantities of the foreign metals mentioned above. For instance, nickel smelted in the old way from speiss always contained arsenic. The introduction of nickel alloys was thus prevented for a long time. Nickel is used in alloys either as the spongy mass which is produced by carbon reduction of the oxide, as Mond pellets, or as the oxide, the latter being largely used for nickel-steel. Nickel alloys containing more than 25 per cent. of nickel are always white, owing to the great colouring power of the metal.

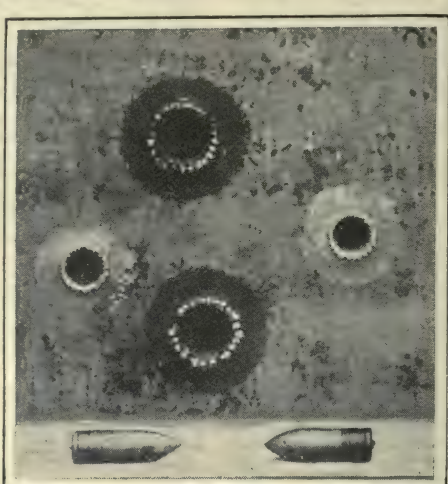
German Silver. German silver is a brass with the addition of nickel. It is an alloy in widespread use, and was prepared by the Chinese, long before nickel was known as a metal, by melting copper with nickeliferous minerals. It was similarly prepared in Europe in 1770. It is also known under the names nickel silver, argentan, neusilber, packfong ("white copper") and maillechort. Nevada and Virginia silver, silveroid, silverite, electrum, etc., are varieties of the same alloy, with different proportions of the constituents, and, perhaps, also containing cobalt, iron, or manganese. German silver is valuable on account of its whiteness and capacity for polish, hardness, toughness, malleability and ductility, and its chemical resistance to air and weak food acids. German silver is crystalline, and cast plates crack on hammering. The crystalline structure is destroyed by rolling and hammering operations, with frequent annealings, and the metal is then easily worked under the stamp or in the rolls, provided the metals used in alloying are pure. In making German silver, the alloying metals are used as binary alloys—a nickel and copper alloy being mixed with brass. Modern proportions for the alloy vary very considerably. Some of the representative formulæ are given in the following table.

COMPOSITION OF GERMAN SILVER ALLOYS

Name.	Nickel.	Copper.	Zinc.	Remarks.
The ideal alloy	34	46	20	The best for beauty, lustre, and working
Extra white metal	30	50	20	
Berlin argentan	26	52	22	
Electrum	25·8	51·6	22·6	
For spoons, forks, etc.	25	50	25	Blue-white, untarnishable
Coin metal	25	75	—	Continental coinage
White metal	24	54	22	
Sheffield	24	57	19	
Best best	21	50	29	
Firsts	16	56	28	
Packfong	15·6	43·8	40·6	Chinese alloy
Thirds	12	56	32	
Fifths	7	57	36	For plated goods

Platinoid is a German silver with 2 per cent. of tungsten added. It has the properties of German silver, but its electric resistance is $1\frac{1}{2}$ times greater, and changes only 0·0209 ohm per degree between 0° C. and 100° C., whereas German silver changes 0·044 ohm per degree, and copper 0·38. Its resistance, therefore, being very high, and approximately constant, it is largely used for resistance boards and similar purposes.

Nickel - steels. Nickel added to steel raises its elastic limit and tensile strength and increases its hardness and its resistance to alternating stress, impact, or shock without seriously lowering its extensibility. It had long been noted that meteoric iron is tougher, more malleable, and less easily corroded than ordinary iron, and it was known that nickel was present, but it was not until pure nickel was obtainable that alloys with iron were successfully made. Most hardening constituents of iron and steel make the metals brittle, but nickel and manganese are exceptions.



3. STEEL PLATE PERFORATED BY PROJECTILES

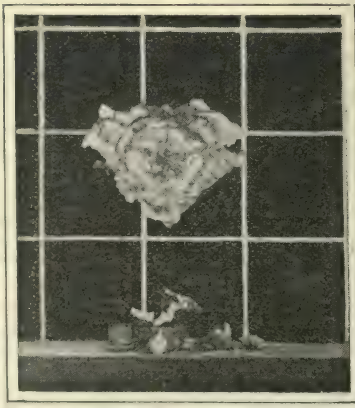
COMPARATIVE STRENGTHS OF REPRESENTATIVE NICKEL-STEELS

Authority.	Condition.	Nickel. Per cent.	Carbon. Per cent.	Manganese Per cent.	Elastic limit. Tons per sq. in.	Maximum Stress. Tons per sq. in.	Area reduction. Per cent.
Arnold ..	—	1·51	0·11	—	22·45	26·8	62
Sankey & Smith	Annealed	2·95	0·32	0·512	21·7	39·3	58·6
	Do. (Sheffield) ..	3·01	0·28	0·516	21·9	39·2	49·3
	Oil-tempered (German)	4·175	0·31	0·615	23·7	50·4	54·3
Riley ..	Rolled and annealed	5	0·5	0·34	32·5	46·8	—
	Do.	25	0·82	0·52	15·1	42·1	43·6

The strength factors of representative nickel-steels are shown in the table given above. For ordinary soft steel the limit of elasticity is about 13 tons, and the ultimate strength from 22 to 35 tons per square inch.

The combination of ductility with strength and hardness particularly fits nickel steel for armour, and it is probable that no armour or deck-plate is now made that does not contain from 3 per cent. to 5 per cent. of nickel. The best armour plate yields by perforation rather than by fracture. Nickel-steel armour was adopted by the British Navy in 1896. In an official test made some years ago an ordinary face-hardened (cemented) plate cracked and fractured under test, while a Krupp nickel-steel plate, 6 in. thick, which was attacked by guns of equivalent weight, did not crack, and the projectiles rebounded, owing to the elasticity of the plate. The projectiles, which were fired at a hardened nickel-steel Vickers plate, 11·8 in. thick, would have perforated an iron plate 26 in. thick, but they broke against this plate, leaving their heads imbedded, without cracking it. Krupp plate contains 3·5 per cent. of nickel, 1·5 per cent. chromium, and 0·25 per cent. carbon.

Results of recent armour plate trials by Messrs. Vickers, Sons, & Maxim, Ltd., are shown in **3** and **4**. The former [**3**] is reproduced from a photograph of a 4-in. plate made of non-cemented steel, which has been completely perforated by four projectiles, 4 in. and 3 in., two of which are shown in the photograph, practically undamaged. The latter [**4**] shows part of a 1906 cemented nickel-steel $5\frac{3}{4}$-in. Vickers plate which completely broke up a 6-in. shot, the fragments being shown at the bottom of the photograph.



4. NICKEL-STEEL PLATE AGAINST WHICH SHELL HAS BROKEN UP

On account of its high elastic limit, nickel-steel is of great importance for gun-steel in combatting the fatigue induced by repeated high firing stresses. Its high elastic limit, combined with ductility, also give it value for marine shafting where there are continual variations of alignment, owing to wave shocks, the indefinite repetition of which means rupture of the shaft. The use of a 3·25 per cent. nickel-steel shaft instead of ordinary steel multiplied by six the number of rotations before breaking. In a series of American flexure tests, a 5 per cent. nickel-steel tube bore 1,000,000 flexures, compared with 100,000 for a 0·1 per cent. carbon steel. Its resistance to alternating stress and shock render it exceptionally serviceable in high-speed engine parts, marine shafting (as mentioned above), girders, stanchions, railway axles and tyres, and hull plates (nickel-steel is less corroded in salt and fresh water than steel), where rigidity without brittleness is required. Its greater strength permits decrease in weight, or an increased safety factor. It is also of value in tool-steels, steam-hammer and rock-drill piston rods, hydraulic cylinders, and similar high stress apparatus.

Cobalt has a similar influence on steel, but its limited supply prevents it competing with nickel.

Nickel-steel is made in the open-hearth furnace, in the ordinary way, with ferro-nickel or nickel oxide.

Cobalt Compounds. Cobalt would compete with nickel in many respects if it were obtainable in greater quantities, but, the supply being limited, its compounds are the only forms in which it is used.

Cobalt forms two oxides—the protoxide, CoO, and the sesquioxide, Co_2O_3. The protoxide forms numerous salts. The chloride and nitrate in weak solution forms sympathetic inks, turning bluish green on heating, fading away again, if they are not too strongly heated to form a basic salt. The sesquioxide is of no practical value. It forms no salts. The protoxide is the basis of all blue colours used in glass and porcelain work. *Smalts* is a glass-cobalt oxide, melted with quartz sand and potassium carbonate. Fine smalts was used for bluing paper, but is superseded by artificial ultramarine. *Zaffre* is a fritted silicate made by heating the oxide with quartz. It produces a deep blue glass when fused with a carbonate. Other cobalt colours are *cobalt blue* (a mixture of the hydrated oxides of cobalt and aluminium), *Thenard's blue* (cobalt and aluminium phosphate), and *Rinman's green* (zinc and cobalt oxides).

In making smalts, fairly pure arsenical ores are calcined in a reverberatory or muffle furnace (with arsenic condensing chambers), mixed with glass-house sand and potassium carbonate, and fused in glassmakers' pots.

LEAD

Lead is one of the oldest metals. As far back as B.C. 878 a king of Assyria took tribute in galena, and this ore was reduced by crude smelting operations centuries before that date. The Romans conducted huge lead mining operations in the Iberian Peninsula, and Pliny says that they employed about 20,000 slaves in the mines. Lead used up to comparatively recent times was superior to the modern metal in colour and durability, owing to the presence of a small proportion of silver, which is now almost completely removed.

Properties of Lead. Lead, when pure, is a bluish grey metal, and is soft, plastic and viscous. It can be cut with a knife, and clean surfaces can be welded in the cold by pressure. It is almost non-elastic. A wire $\frac{1}{10}$th in. in diameter breaks under a strain of 30 lb. Lead met with in commerce is practically pure, owing in part to the rigid refining it undergoes for the recovery of the silver. It is the heaviest of the ordinary metals of commerce (S.G. = 11·35). According to Fizeau, its coefficient of expansion is 0·002948; its specific heat is 0·0314 (Regnault). It melts at 326° C., and contracts on solidifying. A film of oxide is rapidly formed in air, but increases very slowly. Pure water by itself is without action on lead, but if air be present a hydrated oxide is formed, which is soluble. Further, carbon dioxide, if present, makes this process of lead corrosion and solution a continuous one by precipitating the hydrate as carbonate as it is formed. There is, accordingly, danger in the use of lead pipes and tanks for the distribution of *pure* water; but, fortunately, drinking water is rarely chemically pure, and generally contains the small proportion of carbonate or sulphate of lime which suffices to prevent this action. Nitrates and nitrites increase it. Even the pure waters of Loch Katrine appear to act so slowly on the Glasgow lead piping that short service-piping seems to be without danger. Lead cisterns and domestic utensils of lead are, of course, highly dangerous. Dilute sulphuric acid is without action on lead, but when concentrated and heated, it forms the sulphate. Dilute nitric acid readily dissolves lead.

Lead Ores. Lead occurs native, and mineralogists recognise some sixty ores, but, metallurgically, there are only three ores: (1) *Galena* (PbS), containing 86·6 per cent. of lead; (2) *Cerusite* ($PbCO_3$), 77·5 per cent.; and (3) *Anglesite* ($PbSO_4$), 68·3 per cent. The distribution of galena or other ores is almost universal.

Galena is the principal lead ore. It is by far the most abundant, and is also the chief smelting mineral for silver, of which it contains from 0·01 to 0·3 per cent. as sulphide (= from 3 oz. to 113 oz. per ton). It contains from 83 to 86 per cent. of lead, and from 1·3 to 16 per cent. of sulphur. Galena occurs in a great many geological formations. The principal mines of the world are those of the South of Spain and of Missouri, Utah and Mississippi, in the United States. The galena mines of Broken Hill, New South Wales, and of Queensland are worked chiefly for their silver contents.

Anglesite and cerusite are generally found as surface deposits in galena mines, and are, in fact, atmospheric oxidation products of galena, as may be seen from their chemical composition—$PbO.SO_3$ and $PbO.CO_2$, anglesite being an intermediary stage in the production of the carbonate. The carbonate is sometimes found crystalline as cerusite, but more often occurs in earthy masses mixed with clay, limestone, iron oxide. The largest mines are those of Nevada and Colorado, in the United States of America, where the ore occurs in pockets in limestone. The Colorado ore contains from 0·1 to 2 per cent. of silver, and was originally worked chiefly for that metal. The sulphate (Anglesite, $PbSO_4$) is found in the United Kingdom, the United States, France, and Germany, but its distribution is limited. It is smelted with galena ores.

The arsenate (Mimetesite, $PbCl_2.3Pb_3As_2O_8$) is found in galena veins to a small extent in England and Saxony. Flint-glass makers use it. British lead and lead-silver ores (principally galena) are now mined only in Derbyshire, Flintshire, and the Isle of Man. Scottish, Irish, and West-country mines closed down some years ago owing to exhaustion or unprofitable working.

Treating the Ores. The treatment of galena is practically the treatment of lead ores in general. Separate processes for other ores are rarely used, and only on a much smaller scale. The carbonate and sulphate are oxidised forms of the sulphide which have been oxidised slowly by atmospheric agencies instead of rapidly in the furnace. They are generally smelted with the sulphide.

The principle of pure galena reduction is, perhaps, the simplest of all ore-reducing operations. It consists of roasting the sulphide until all the sulphur is oxidised, leaving the metallic lead. It is not quite so simple in operation, because galena ore is generally an admixture of lead sulphide with iron, copper, and zinc sulphides, zinc and lime carbonates, and siliceous substances. To concentrate the ore for smelting, these ingredients, which seriously affect the furnace treatment of the ore, are removed by "dressing." This consists of the operations of crushing in stamping mills and separating the particles according to their gravities. by washing in buddles, jiggers, or other separators, Magnetic separators for removing the iron pyrites have come into use in recent years.

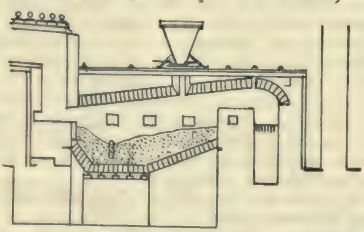
Lead ores are smelted in the reverberatory hearth, or blast furnaces. Practically none but galena ores with little silica can be treated in reverberatories, or low-silver ores on hearths, owing to volatilisation losses. Blast-furnace treatment is successful with all ores, but the lead produced is of lower grade than that resulting from reverberatory or hearth treatment, and these treatments are frequently combined with blast-furnace smelting. Wet processes do not exist commercially.

The principal type of lead reverberatories now used are the English, with its modification, the Silesian. In the English method, large furnaces, built on air-vaults or open underneath to cool the hearth, and high temperatures, are employed. A section of the furnace is shown in **5**. The sole is paved with slag from previous operations, and has a depression where the reduced metal collects and is tapped. The dressed ore is fed in through the hopper. The process consists in the oxidation of the ore by a series of calcinations and roastings, sulphur being eliminated as sulphurous acid, with the formation of lead oxide and sulphate, according to the equations :

1. $2PbS + 3O_2 = 2PbO + SO_2$
2. $PbS + 2O_2 = PbSO_4$

The temperature is then raised by closing dampers and furnace doors, and the oxide and sulphate react with unchanged sulphide, producing a regulus of lead, thus :

3. $PbS + 2PbO = 3Pb + SO_2$
4. $PbS + PbSO_4 = 2Pb + 2SO_2$

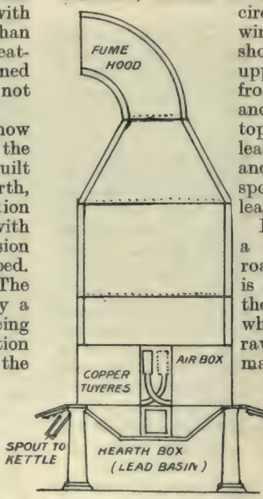


5. ENGLISH LEAD REVERBERATING FURNACE

These two operations of oxidation and reduction are repeated several times until the lead extraction is complete. Slaked lime is added to keep the charge from melting (reaction does not take place in fused ore). It also decomposes the sulphide. This is known as the *roast and reaction* method.

In the Silesian furnace a low temperature is used, giving a slag rich in lead (50 per cent.), which is smelted in the blast furnace. Volatilisation losses are thereby reduced, and a higher yield ultimately obtained.

The ore-hearth process resembles that of the reverberatory, with the difference that oxidation and reduction are simultaneous, the oxide and sulphate reacting with sulphide as soon as they are formed. In this process the ore is smelted in contact with the fuel by the action of a blast on the fuel, the principle being the same as that of the blacksmith's forge. The fuel consumption is about half that of a reverberatory, and the process is readily started and stopped, but the volatilisation losses are higher, and the process is of most value in places where labour is cheap and fuel dear, such as Mexico. Modern hearth-furnaces are water-jacketed, use hot blast, and produce large quantities of lead fume, which, when drawn off and filtered through woollen or cotton bags, form a good white paint, containing about 65 per cent of lead sulphate, 26 per cent. of lead oxide, and 6 per cent. of zinc oxide. The Moffet hearth-furnace, one of the most modern, is shown in **6**. It consists of two hearths separated by a hollow partition, in the lower part of which water is circulated for cooling. The wind chest for the blast (not shown) is connected with the upper part of the partition, from which tuyeres descend and deliver the blast at the top of the hearth-box. The lead overflows from the hearth, and is delivered through a spout in the work-plate into a lead kettle.

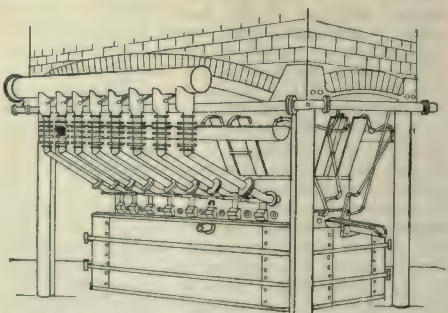


6. MOFFET DOUBLE-HEARTH FURNACE FOR LEAD

In blast-furnace treatment a preliminary reverberatory roasting, or "lime-roasting," is always carried out, unless the silver content is high, when the ore is smelted raw. The ore treated is then mainly oxide, with some sulphate and sulphide, as well as metallic constituents. The reaction is largely one of reduction of the oxide by the fuel (carbon) and the carbon monoxide produced by the action of the tuyeres' blast on the carbon, the heat of combination being sufficient to melt the slag and metal. The sulphate becomes sulphide, and, combining with copper, zinc, iron, and other metals present forms a matte, while silicates with any unreduced oxides form a fusible slag. Precipitation of the metal from the sulphide melt is also effected by the iron present.

A lead blast or shaft furnace has been shown [see **26**, page 4125], and a modern rectangular furnace is given here [**7**].

Furnace Products. The principal smelting products are work-lead (base bullion), matte, flue-dust or fume. Flue-dust, or lead fume, is present in considerable quantities in furnace smoke, and to permit it to pass into the atmosphere would be a serious menace to the public health, besides causing loss to the smelter. It consists of a mixture of lead sulphides, sulphates, and oxides, with some zinc and other substances in the



7. RECTANGULAR BLAST FURNACE FOR LEAD

form of an infinitesimally fine dust. Condensation is effected by air or water cooling, the former requiring long flues. Formerly, it was accomplished by a mere lengthening of the flues, those at Freiberg,

in Saxony, having been added to until they reached the extraordinary length of five miles. The fume is collected in settling chambers or in the bags already referred to. Besides being used as a natural paint, flue-dust is made into bricks with lime, and reduced in the furnace. It may be added as dust in small proportions to each furnace charge.

The sulphide mattes formed are granulated, re-roasted, and smelted in the blast furnace.

All the furnace processes produce lead in the form of work-lead, which contains the bulk of the silver and gold present in the one (if it be argentiferous), and also copper, arsenic, antimony, and iron as impurities. The latter metals render the lead hard and unsuitable for desilverising, and their removal is a preliminary necessity.

"Softening," or "improving," as it is called, which is the oxidation of these impurities in cast-iron kettles or reverberatory furnaces, is the next process, the liquated oxides being removed as a scum. Antimonial dross is worked up for Britannia, type, and other similar metals. If the lead be non-argentiferous (such as that produced from the ores of Missouri and part of Spain), this is practically all the refining that is necessary.

Desilverisation. Most lead is argentiferous, and recovery of the silver is an important part of the business of the lead-refiner. It is effected by cupellation [see pages 4303 and 5848], or by the Pattinson or Parkes alloy processes.

At one time the silver was recovered by cupellation alone, the whole of the lead being converted into oxide, which was reduced by re-smelting with carbon. This was costly, and very wasteful of lead, and direct cupellation is now used only in Mexico or parts of South America for very rich lead, where the silver is the only metal sought. Cupellation is, however, the final process in the separation of the silver from the alloys produced by the Pattinson and Parkes processes. Both these processes produce (1) marketable lead, and (2) a much smaller amount of a rich silver-lead or silver-zinc-lead alloy.

The Pattinson process depends upon the fact that silver in quantities up to 2¼ per cent. (700 oz. per ton) lowers the melting point of a lead-silver alloy, while larger proportions raise it. If molten argentiferous lead, therefore, be slowly cooled, the portion first crystallising out contains but little silver, the liquid portion being a eutectic alloy containing about three times as much of the metal. This crystallised lead can again be separated into two portions until lead, silver-free, and containing from 500 oz. to 600 oz. of silver per ton, is obtained. The Luce-Rozan modification of the process is now used. In it the formation of the crystals is promoted by blowing steam through the melt, thereby separating out impurities to the extent of ⅔ per cent., and the fluid eutectic alloy is tapped off, leaving the crystals behind, which are melted and cast for the market.

The Parkes process is based on the facts (1) that silver alloys more readily with zinc than with lead, and (2) that a silver-zinc alloy of lead is less fusible and lighter than lead, and is, therefore, separated from and floats on the surface of a lead melt. For this process it is essential that the zinc and lead should be practically pure. Molten lead from the "improving" furnace is tapped into cast-iron kettles holding about thirty tons, and a small amount of zinc stirred in. The crust which forms contains all the gold and copper present, with some silver. It is worked up separately to doré silver. The lead is now saturated with zinc, and on again adding zinc, most of the silver is collected in the crust. This is worked up to fine silver. A third addition of zinc reduces the silver to about 0·0003 per cent., the unsaturated crust being used in the second zincing of the next charge. The lead-zinc-silver alloy is liquated from the crusts in a reverberatory furnace, and the zinc recovered by distillation in a pear-shaped plumbago retort. The Parkes process is cheaper than the Pattinson (Rozan), but it does not remove bismuth, and the two processes may be combined for a base bullion containing appreciable amounts of bismuth.

Cupellation. The concentrated lead-silver alloys produced by these processes are finally separated by cupellation, the principles of which have already been explained [page 5848]. The English reverberatory furnace used for cupelling is oblong, and has a movable iron hearth, which is lined with a mixture of crushed limestone and clay, or Portland cement mixed with crushed firebrick. Bone-ash is no longer used. On a large scale, the smelting is made continuous by the addition of charge-lead until the charge contains from 60 per cent. to 80 per cent. of silver. Cupellation of the concentrated bullion from several furnaces is finished in a separate furnace, the silver being refined at the same time. The litharge produced may be sold as such or reduced to metallic lead. Refined and desilverised lead is not less than 99·98 per cent. pure.

Uses of Lead. Owing to its chemical inertness and great power of resisting corrosion by moisture and atmospheric agencies, lead is a valuable covering for roofs. It is extensively used for the same reasons, and because of its plasticity, in sheet form for gutters, ridges, and other building purposes [see page 358], and for lining vats, tanks, and chemical works' apparatus. Sheet lead is made by casting flat ingots in moulds holding several tons, and passing them several times through rolling mills until they weigh about 30 lb. to the square foot. It is cut into smaller sheets on the mill bed and rolled to the weights required for the market. Very thin sheets for tea-chest linings are made in the East by pressing molten lead between tiles faced with unsized paper. Tinned leadfoil is lead rolled and re-rolled between layers of tin to the thickness desired. Lead piping is made in an hydraulic press [see pages 359, 5326, and 5627]. "Compo" pipe is lead piping hardened by alloying with antimony or tin. It is largely used in gasfitting. Large quantities of lead are also used for the plates of electric accumulators. In alloys and compounds lead has a very wide use.

Lead Alloys. The compositions of some of the pricipal alloys of lead are shown in the table on the next page.

Lead unites with most metals in all proportions. With tin it forms a valuable series of alloys of which the most important are the pewters and solders. Lead increases the malleability and ductibility of tin, but diminishes its tenacity and toughness. Pewter is now being replaced largely by unalloyed tin, which is whiter and safer for domestic purposes. The three grades of soft solder melt at 213° C., 210° C., and 206° C., respectively. "Plumbers' sealed solder," stamped by the Plumbers' Company, passes through a prolonged pasty stage as it cools, which is the state in which the plumber uses it in wiping a joint. It is due to the fact that the alloy has two points of solidification, one for the eutectic alloy contained, and another, much higher, for the excess of solid lead. The pasty mass, in fact, consists of a large proportion of

granular lead in a mother liquor of the fluid eutectic. Antifriction metals are very numerous, and the same name is given to many different formulæ. Fusible metals are largely used in safety devices actuated by sudden or excessive increase of temperature. The three given above melt below the boiling point of water. They are also used for taking casts of delicate objects.

Arsenic increases the fusibility of lead and also hardens it. In shot metal, which falls from a height into water, it enables the drops of metal to assume a spherical shape in falling. The perforations in the basin at the top of the shot-tower are regulated according to the size of the shot required, and to prevent the drops of molten lead joining together in their fall, the holes are of irregular size, one being three times the diameter of the next and so on. In an American modification of the usual process, air is forced up a short tower at a high velocity so that the descending lead comes in contact with as much air as it would in a high tower. A centrifugal modification has also been introduced in which the metal is poured on a rapi lly revolving disc from which it is thrown against a screen, in the form of drops.

COMPOSITION OF LEAD ALLOYS

Alloy.	Lead.	Tin.	Antimony.	Bismuth.	Copper.	Other Metals.
Pewter, common ..	20	80	—	—	—	—
,, good	14·25	85·75	—	—	—	—
,, best	—	99·5	—	—	0·5	—
Soft solder, common ..	50	50	—	—	—	—
,, ,, coarse (" Plumbers' sealed ")	66·65	33·35	—	—	—	—
Soft solder, fine ..	33·35	66·65	—	—	—	—
Antifriction metals ..	55	40	5	—	—	—
,, ,,	85	—	10	5	—	—
Babbitt	40	45·5	13	—	1·5	—
Magnolia	78	6	16	—	—	—
Fusible metals:						
Newton's	31·25	18·75	—	50	—	—
Wood's	24	14	—	50	—	Cd 12
Lipowitz's	27	13	—	50	—	Cd 10
Shot-metal	99·1	—	—	—	—	As 0·9
Type-metal	83	—	17	—	—	—
Stereotype metal ..	69·3	—	15·35	15·35	—	—

Type metal is a lead alloy which has been made hard and expansible on cooling by the addition of antimony. Bismuth and tin increase its resistance to the crushing action of the press.

Lead Compounds. The most important compounds are white lead, a basic carbonate ($2PbCO_3.Pb(OH)_2$), litharge and massicot (PbO), and red lead, or minium (Pb_3O_4).

White lead is the most important of the lead compounds, and the most important of all pigments, forming the basis of nearly all ordinary paints. It possesses the greatest covering power and partially combines with oil, drying hard and homogeneous. It is, however, a very poisonous body, and is darkened by the action of sulphuretted hydrogen. Zinc white is its most important competitor, but it is deficient in covering power and dries slowly.

"Genuine" white lead is that prepared by the old Dutch method and consists of a spongy, transparent globular powder, the globules absorbing oil. Basic lead carbonate prepared otherwise is a dense crystalline powder, containing more carbonate and less hydrate, and the crystals do not absorb oil. In the Dutch method, lead, cast into the form of thin gratings, is stacked in brickwork chambers in layers on a bed of fermenting tan on which are placed earthenware pots containing a 3 per cent. solution of acetic acid. The stack is left for from 14 to 15 weeks. The fermenting tan supplies heat, to volatilise the acid solution, and also carbon dioxide to convert the coating of lead acetate formed on the plates into carbonate. This is detached, ground, washed, and dried, and the lead remaining used for the next corrosion. Many processes have been devised for producing the basic carbonate by less costly means, but none, so far, have succeeded in producing the amorphous compound. One which is largely used consists in treating very finely-divided lead in a rotating drum with acetic acid for seven days, air, fire-gases, and steam being blown in. The carbonate produced is ground and treated with soda in settling tanks. The best substitute, says Professor Church, is Freeman's white, which is a mixture of lead sulphate with zinc oxide and a little baryta. Others are lead sulphite, sulphates and carbonates of barium, strontium and calcium, or mixtures thereof with white lead.

Litharge and massicot are the saem oxide, but litharge is prepared above the melting point of the oxide and massicot below. The former is reddish yellow and crystalline, and the latter an amorphous lemon yellow powder. Litharge is used for the manufacture of other lead compounds of drying oils, oil varnishes, cements, for the lead plaster of pharmacy, and as a glaze for earthenware. Massicot is used for drying oils, as a pigment, in flint glass, and for the preparation of red lead.

Litharge is obtained either as the by-product of cupellation o: by oxidation of the metal in a reverberatory furnace. If it be gradually cooled it partially flakes. It is sent to the market in the levigated form, produced by grinding, washing, and drying. It is also made direct from the ore. Massicot is prepared from the metal at a low heat on a reverberatory hearth.

Red lead, or minium, is prepared from yellow massicot (made by "drossing" lead) by heating it for 45 to 48 hours in a furnace known as the "colouring oven." Ground with linseed oil as a paint it forms a good protective covering for iron and other metal surfaces. It is also an ingredient in certain cements, and in flint glass.

ALUMINIUM

Aluminium, or aluminum, as it is frequently called in the United States, is one of the most interesting of the metals now in common use. Its history is not long, compared with the other useful metals, on account of the comparative rapidity of its development, but it is almost romantic, and every decade is packed with interest. Even now it is probably only in the infancy of its development, though whether that development will be in the metal or its alloys is yet to be seen.

Occurrence. Aluminium is more abundant throughout the world than any similar substance. It is the most widespread element, with the exception of oxygen and silicon (with which it is usually found in combination), and it is computed that it forms 8·16 per cent. of the earth's crust, the next most abundant metal (iron) amounting to 5·46 per cent.

There are four important natural compounds of aluminium—silicate, oxide, hydrated oxide, and fluoride.

All clays consist largely of aluminium *silicate*, and constitute the largest natural source of aluminium. The purest clay is kaolin, or china clay,

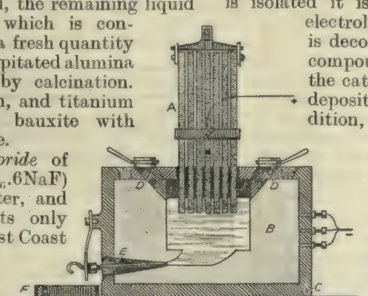
which consists almost entirely of aluminium disilicate ($Al_2O_3.2SiO_2.2H_2O$), of which large beds are found throughout the world, particularly Limoges, Devon, Cornwall, and the United States.

Kaolin contains 39·8 per cent. of alumina, and would thus seem to be the best ore, but since no satisfactory process for separating the alumina and the silica has been discovered, it is not available at present. If it were, nothing could compete with kaolin as an aluminium ore. Common clays are either impure kaolin or else contain a larger proportion of SiO_2, ranging up to 70 per cent.

The *anhydrous oxide* occurs as corundum and emery, and as gems—sapphire, ruby, etc. Corundum contains 52·9 per cent. of aluminium, the highest percentage of any ore. Large deposits occur in South India and the United States. It is not used as an ore, on account of its excessive hardness, which gives it more value as an abrasive.

Bauxite. The *hydrated oxide* (hydroxide) occurs largely and widely as bauxite (principally $Al_2O_3.2H_2O$), and also much less frequently as diaspore ($Al_2O_3.H_2O$). Bauxite is the source from which the metal is obtained by all the processes now in use. It was first found near Baux, Département de Var, in the South of France, where there are beds 36 ft. thick and nearly 10 miles long. The most important beds are in the South of France (Baux), the North of Ireland (Antrim), and Alabama and Georgia, in the United States. Bauxite is usually found in association with ferric oxide, silica, and, particularly in American ores, with titanic acid. It is usually pisolitic in structure—that is, in pea-like globules—and when free from iron, is of a creamy white colour. Irish bauxite is of the average composition: Al, 56 per cent.; FeO, 3 per cent.; SiO_2, 12 per cent.; titanic acid, 3 per cent.; and H_2O, 26 per cent.

For electrolytic reduction, the ore is first calcined at a low temperature, to destroy organic matter and to convert the iron completely into the peroxide; then it is steam-heated under pressure with caustic soda solution, and filtered. The sodium aluminate thus produced is treated with pure aluminium hydroxide, by means of which about 70 per cent. of the alumina is precipitated, the remaining liquid being mainly caustic soda, which is concentrated, and used to treat a fresh quantity of calcined bauxite. The precipitated alumina is filtered and dehydrated by calcination. Reduction of the iron, silicon, and titanium is also effected by fusing bauxite with carbon in an electric furnace.



8. HEROULT ALUMINIUM FURNACE

a. Bundle of electrodes *b.* Carbon lining forming cathode *c.* Steel cell gates *d.* Alumina supply *e.* Tapping vent *f.* Receiving mould

Cryolite is a double *fluoride* of aluminium and sodium ($Al_2F_6.6NaF$) with some ferric oxide, water, and other impurities. Almost its only source is Ivigtuk, on the West Coast of Greenland, and its consequent inaccessibility, combined with its general impurity, have caused it to be abandoned as an aluminium ore, though it was the basis of several of the older processes. The double fluoride is used as a solvent for alumina in modern electrolytic processes, but it is artificially prepared.

The alums, which were the subject of the early investigation and from which the metal derives its title, include a number of double sulphates of aluminium and another metal (such as $K_2SO_4.Al_2(SO_4)_3.24H_2O$) containing much water of crystallisation. On calcination they give more or less pure alumina. They are of little practical interest in connection with the production of aluminium.

Electrothermic Reduction. No aluminium has been made by purely chemical methods for several years. The heat of combination of aluminium in forming the oxide (alumina) so greatly exceeds that of other common metals that the only feasible processes of reducing alumina by means of the ordinary reducing agents (carbon, etc.) are electrothermic. Electrical processes are of two kinds — *electrothermic* and *electrolytic*. Electrothermic processes are those in which the current acts merely as a heating agent, either by means of an arc or by the resistance of the substance treated. No purely electrothermic process is now used. The most successful was the Cowles, which produced, not aluminium, but alloys, principally aluminium bronze, in the days when the alloys were more valued than the pure metal. Rectangular fireclay furnaces [the same furnace used for calcium carbide production is shown on page 5758] were charged with a mixture of alumina, or other ore, alloying metal and charcoal. A current of from 3,000 to 5,000 amperes was used, the alumina being reduced solely by the carbon of the electrodes in the great heat produced by the resistance of the furnace contents to the current. It was not possible to predetermine the composition of the alloys so that each batch was analysed and then re-melted, copper or iron being added as required. Much alloy was turned out by the Cowles Syndicate, but since the great cheapening of the pure metal, alloys have been exclusively made by melting with aluminium.

Reduction by Electrolysis. No one has so far succeeded in producing aluminium by any practical process of electrolysis from aqueous solutions without the use of soluble aluminium anodes. In the first place, although aluminium in mass is unattacked by water, yet the foil is rapidly oxidised by boiling water, and it is quite probable that the reason why aluminium is not easily deposited in aqueous solution is that, like sodium, as soon as it is isolated it is attacked. Further, in aqueous electrolysis of aluminous solutions water is decomposed, along with the aluminium compound, producing nascent hydrogen at the cathode. This causes the metal to be deposited in a finely-divided spongy condition, in which it readily attacks the water, being oxidised in the process. Electrolysis of fused alumina dissolved in a bath of cryolite (the double fluoride), kept molten by the heat due to the resistance offered by it to the passage of the current, is the principle of the processes now in use.

The details which follow concern the Héroult patents which are worked in England (by the British Aluminium Co.) and on the Continent. The Héroult furnace is shown in **8.** Similar processes under the Hall patents are worked in the United States by the Pittsburgh Reduction Company.

The furnaces used are iron cells lined with carbon and rectangular in shape, the internal area being about 5 ft. by 2½ ft. The negative pole of the dynamo is connected with a steel plate in the bottom of the cell or with the cell itself, in contact with which the

molten reduced aluminium acts, in practice, as the cathode. The anode is a bundle of carbon rods dipping into the electrolyte and capable of vertical adjustment.

The charge of cryolite is placed in the cell, and fused by the current. Pure powdered alumina is then fed in continuously while the operation proceeds. A current from 3 to 5 volts at a density of about 700 amperes per square foot, or 8,000 amperes per cell, is sufficient to maintain the temperature and the electrolysis. As part of the voltage is consumed in overcoming the resistance of the bath (thereby heating it), and as decomposition of cryolite theoretically requires 4 volts, the cryolite solvent is not attacked at all, if the bath be properly supplied with alumina. Therefore, except for mechanical losses, it lasts indefinitely and its impurities are not transmitted to the metal. Careful purification of the alumina and of the anode and lining carbon is all that is necessary to produce a pure metal. The result of the electrolysis is the splitting up of the alumina into aluminium (which, being slightly heavier in the molten state than the fused cryolite, sinks to the bottom of the cell, where it is run off) and oxgyen, which combines with the carbon of the anode to form carbon monoxide, the gas being burnt to dioxide outside the cell. The carbon consumed in this way is about equal in weight to the aluminium produced. The yield of metal in practice is ½ to ¾ lb. per 12 E.H.P. hours.

The advantage of combining internal heating with the electrolysis is that it enables the cells to be kept comparatively cool; if they were heated externally (as was proposed) they would have to be hotter than the electrolyte, and there is no suitable material that is able to withstand the action of nascent aluminium at high temperature.

Impurities. The principal impurities in reduced aluminium are silicon, carbon, iron, copper, lead and zinc. The last three, which, in very small proportions do not seriously affect the metal, and are not usually found, are partially removed by remelting. But no satisfactory methods of refining aluminium have yet been described. It can be purified absolutely by laboratory processes, but these are not industrially possible, and commercially, most of the impurities, particularly the important ones—silicon, carbon, and iron—are not removable. The metal has accordingly to be produced as pure as possible, and this is the reason why the alumina has to be so carefully purified. If refining were possible, aluminium could be reduced direct from bauxite, and so a considerable proportion of the expense of reduction would be saved. This remains to be accomplished.

Physical Properties. As in the case of iron, the physical properties of aluminium are considerably affected by the presence of small quantities of other constituents; but aluminium has not had, so far, the advantage of the comprehensive micrographic, physical and chemical research which has been bestowed on the varieties of iron, and much has yet to be learnt of the individual and collective influences of the minor ingredients of commercial aluminium. Silicon and iron are present to the extent of 1 per cent. in most commercial metal, and, in that proportion, slightly lessen its malleability. Two per cent. makes it brittle. Carbon in the smallest proportion markedly deteriorates it.

Pure aluminium is absolutely white on fracture. Commercial metal has a bluish tinge due to the presence of silicon, the tint deepening with the amount of impurities. Pure metal is distinctly softer than the commercial, but it is not so soft as pure tin. Drawing or rolling in the cold gives it nearly the hardness of brass.

The wonderful lightness of aluminium is its distinguishing economic feature. When pure, its specific gravity is 2·58 and 2·6 to 2·7 in the case of good commercial metal. The subjoined table demonstrates the advantage thus possessed by aluminium over other metals.

WEIGHT OF ALUMINIUM AND OTHER METALS

Metals.	Weight of Metals, Aluminium = 1.	Cubic in. per lb.
ALUMINIUM	1	11·2 to 10·65
Zinc	2·63 to 2·79	4·07 to 3·84
Iron, cast	2·79	3·84
Tin	2·8 to 2·9	3·79 to 3·56
Tin-plate	2·9 (about)	3·5 (about)
Iron, sheet and wrought	2·94 to 2·98	3·6 (about)
Steel	3·02 to 3·06	3·55 to 3·5
Iron, pure	3·04	3·54
Nickel	3·1 to 3·4	3·4
Brass (Cu 67%, Zn 33%)	3·2 to 3·29	3·33 to 3·25
Bronze (Cu 84%, Sn 16%)	3·25	3·29
German silver (20 %)	3·33 to 3·37	3·22 to 3·18
Copper	3·4	3·11
Silver	4·06	2·63
Lead	4·4	2·47
Gold	7·4	1·43
Platinum	8·3	1·28

The figures in the last column emphasise a fact which is liable to be overlooked. Metals are sold by weight. The capacity of a kettle is dependent on the volume of metal used. Its weight is merely a nuisance. Hence, since tin-plate is nearly three times as heavy as aluminium, the weight of metal which will make one tin kettle will make three aluminium kettles. Accordingly, whenever the cost of aluminium is less than three times that of tin-plate, aluminium is really cheaper. The relative costs in the following table will facilitate comparisons with other metals.

These figures are based on 1906 market prices. They can only be roughly approximate.

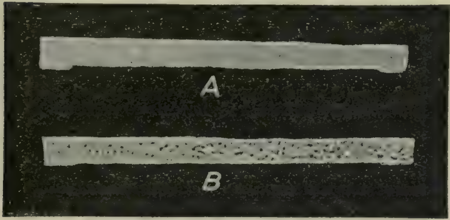
Aluminium melts at about 625° C., at a red heat and, at the temperature of the electric furnace, volatilises. Its mean specific heat is 0·2270, and its latent heat of fusion (that is, the amount of heat required to fuse it at the melting point) for 99·93 per cent. metal is 100 calories, which is more than that of any other useful metal. The consequence of the high value of these two factors is that aluminium melts very slowly even in a very hot fire, and that castings take several hours to cool. Its coefficient of linear expansion is 0·0000231 (Roberts-Austen) or 0·0000222 (Fizeau), which is only less than that of lead and zinc among the useful metals and about equal to tin. Its thermal conductivity is high and surpassed only by copper among the baser metals (Al = 31·33, Ag being 100, Cu 73·6, and steel 11·6).

COST OF ALUMINIUM AND OTHER METALS

Metals.	Approximate manufacturing cost in pence per lb.	Approximate relative costs of equal masses.	Approximate relative costs of equal volumes.
ALUMINIUM	21·3	100	100
Aluminium bronze	24	112	324
Tin	20	82	270
German silver	12	52	209
Copper	11	51·5	182
Bronze and brass	5·8	27	86
Zinc	5·4	25	67
Tin-plate	1·39	6·5	19·5
Steel	·52 to ·69	2·4 to 3·2	7 to 9
Iron, cast and wrought	1·3	1·4	3·5

The relative electrical conductivity is put by Richards at 59 for 99 per cent. metal compared with copper 100 and iron 14 to 16. An aluminium wire that would carry the same current as a copper one would weigh only half as much. Aluminium is non-magnetic. It is very sonorous and is accordingly used for sounding boards.

Cast aluminium is not very elastic, but it becomes stiffer, harder, and more rigid on working. Young's modulus for the castings is 11,000,000 lb., and 13,000,000 and 19,000,000 lb. for wire and rolled metal respectively.



9. SECTIONS OF STEEL CASTING
a. Improved by aluminium *b.* Without aluminium

The approximate tensile strength of commercial aluminium is exhibited in the following table, the relative strength of other metals (rolled) being included for the purpose of comparison.

It is important to note that the above figures for aluminium are reduced by 50 per cent. if the metal is heated over 100° C.

The relative figures show that, weight for weight, the only metals whose tensile strengths equal and exceed that of aluminium are cast steel and its own alloy, aluminium bronze. That is to say, for purposes where the requirements are strength and lightness, cast steel and aluminium bronze are the only competitors, expense being a secondary consideration.

RELATIVE STRENGTHS OF VARIOUS METALS

Metals.	Elastic limit in tons per sq. in.	Ultimate strength in tons per sq. in.	Relative strength for same weight.
ALUMINIUM, castings..	3	7	—
,, sheet ..	5·5	11	—
,, wire ..	6·5	13 to 29	—
,, rolled bars	7 to 13	12	100
Steel, cast	—	44	135
,, soft	—	33	87
Aluminium bronze ..	—	40	118
Wrought iron	—	29	63
Brass, red	—	20	47
Bronze, gun	—	15	37
Copper	—	14	33

Aluminium is a very malleable metal and can be rolled as easily as gold or silver. It can be beaten out into leaves of the thickness of $\frac{1}{40000}$th of an inch, and has superseded silver leaf for gilders' use. It is only less ductile than gold, silver, platinum, iron, and copper.

Chemical Properties. Aluminium is a trivalent atom of the relative weight 27, its equivalent being 9. Commercial aluminium on exposure becomes coated with a thin film of oxide, similar to that forming on zinc, which gives it a slightly dull appearance. This film thoroughly protects the surface from further oxidation.

The action of water has already been referred to. Sulphuretted hydrogen, which is responsible for the blackening and tarnishing of nearly all other metals, has no action on aluminium in the cold. It is but slightly attacked in the cold by sulphuric and nitric acids, but is dissolved readily in these acids when hot and concentrated, and also in cold concentrated hydrochloric acid.

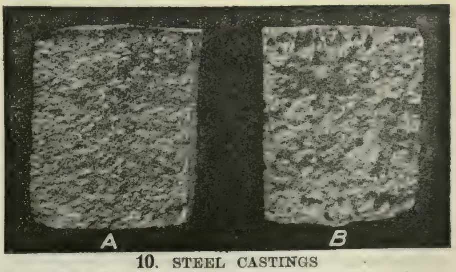
Potash and soda lye and alkalis in general also dissolve aluminium, forming the aluminate. Vinegar, organic acids, salt and food substances in general have very little action on the metal, even when boiling. There is no danger, in the case of culinary vessels, of such traces of aluminium compounds having any injurious action on the human body, for ordinary food contains much more than is so dissolved in cooking and the action is much less than in the case of copper, tin-plate, or iron. Food, particularly fruit, cooked in aluminium vessels is noticeably fresher and better flavoured than when cooked in other vessels.

Working the Metal. If not overheated, that is, much above its melting point, aluminium can be melted in ordinary plumbago crucibles without absorbing carbon or silicon. No flux is needed, nor is it advisable. Only a very thin film of oxide forms on the surface of molten metal, and this, while not spoiling castings, entirely prevents further oxidation. Molten aluminium is viscous and does not run sharply in moulds unless it is under pressure, which is supplied either by giving a head to the metal by means of gates and risers or by air-pressure in air-tight moulds. Sharp castings free from blow-holes are thus readily obtained, and hollow culinary ware as thin as $\frac{1}{16}$ in. is commonly cast. The shrinkage of castings is about 1·8 per cent. of the original volume, or nearly twice that of iron. The difficulty which this causes is also overcome by the use of gates and risers. In rolling or drawing aluminium frequent annealing is necessary, for the metal quickly hardens on working. It is best worked at temperatures between 100° C. and 150° C.

The handsome "mat" or frosted effect which aluminium easily takes is obtained by dipping first in caustic soda or potash solution, then in strong nitric acid, finally washing with water.

Aluminium can be welded, but with difficulty, on account of its high specific heat and because of the soft "mushy" state which it assumes some time before melting.

Soldering. The difficulty of soldering aluminium has been recognised as an obstacle to its use since Deville first produced it commercially, and although innumerable formulæ and processes have been put forward, aluminium is not soldered if other means of uniting pieces of the metal are possible. There are three reasons for the difficulty: (1) the film of oxide which is always present prevents the solder getting to the metal and is not affected by ordinary fluxes and appears to form as quickly as it is removed, if the mechanical means of scratching or filing are used; (2) the high heat



10. STEEL CASTINGS
a. Section with aluminium *b.* Section without aluminium

conductivity of the metal renders local heating to alloying temperature a slow and difficult matter, increasingly so as the bulk of the article worked on increases, and causes the solder to chill quickly; (3) the highly electro-positive character of the metal causes galvanic action with low-temperature solders containing negative metals like lead, the result being disintegration at the joint. It cannot be said that these difficulties have yet been successfully overcome.

Alloys. Aluminium forms a large number of useful alloys, and it is not impossible that its capacity for alloying may eventually provide the greatest field for its development. It unites easily with most of the metals, the combination being usually accompanied by a disengagement of heat particularly in the case of copper. Lead and antimony appear to be the only metals not alloying with it easily. The practical production of these alloys from the metals is, in general, a very easy operation. The aluminium may be melted in a carbon or magnesia-lined crucible, without a flux, and the other metal simply thrown in; it falls to the bottom, melts, and is absorbed by the aluminium.

Most of the alloys thus produced are improved by careful remelting, becoming more uniform, and finally perfectly so, by repeated fusions. Very few of the alloys liquate; in general the alloy acts as a single metal.

The useful alloys of aluminium fall into two groups: (1) aluminium containing 10 per cent. to 25 per cent. of other metals; (2) other metals containing 10 per cent. to 15 per cent. of aluminium. In almost every case, alloys between these limits possess no useful properties, and are mere chemical curiosities. Alloys of the first class are somewhat harder, stronger, and better wearing than the pure metal, while they retain its lightness. They do not, however, resist corrosion so well. In the case of the second class the effect seems to be a notable increase in strength and toughness and a remarkable change in the colour of the metals with high colours.

11. ALUMINIUM UTENSILS

Aluminium Bronze. Of the alloys of the second class, and of all the aluminium alloys, aluminium bronze is the most important. These bronzes are made by adding 2·5, 5, 7·5 or 10 per cent. of pure aluminium to the purest copper (the smallest amounts of iron, antimony, or arsenic in the copper injuriously affect the alloy). They are metals having tensile strengths of from 20 tons to 40 tons per square inch as the percentage of aluminium rises, strengths not greatly inferior to that of the finest steel, which, moreover, are reduced by only one-fourth when the temperature rises to 300° C. These were the alloys made by the Cowles reduction process, but now they are exclusively made by adding the aluminium to molten copper. It is most probable that these alloys are chemical compounds, for after the aluminium has fused on addition to the copper, so much heat is evolved that the crucible becomes white-hot and has to be removed from the furnace, while the proportions of the constituents in the four principal alloys correspond with their formulæ. The alloys have considerable hardness (nearly equal to gun-steel), high elastic limits (about 18 tons in the case of the 10 per cent. alloy), and large extensibility under strain.

Aluminium bronze is not easily worked. It possesses many peculiarities. It can be well worked only within narrow limits of temperature; castings contract on cooling much more than in the case of aluminium, and the alloy can be forged only at a low red heat. It needs frequent annealing during working if worked cold.

Aluminium bronze has some vogue as an anti-friction metal on account of the smoothness which it possesses combined with its hardness and toughness. It is more susceptible to corrosion than aluminium, but it resists the action of sea water, sulphuretted hydrogen, and coal gas well. It can be kept at a red heat for a long time without oxidation. Its specific gravity is only slightly less than that of copper.

The 2½ per cent. alloy resembles in colour gold of low carat alloyed with copper. The 5 per cent. more nearly approaches the colour of pure gold than any other metal; the 7 per cent. has the colour of jeweller's green gold; and the 10 per cent. is a bright light yellow.

The bronze alloys would be advantageous for most of the purposes for which brass or ordinary bronze is used, but as they cost considerably more they are used only where their particular excellence counterbalances the extra cost. Chief of these uses at present is the manufacture of propellers, for which their great strength, freedom from sea-water corrosion, and galvanic action, well adapt them.

Various alloys with copper and zinc containing from 0·1 to 3·3 per cent. of aluminium are known as "aluminium brasses" and are considerably superior to ordinary brass in strength and power of resisting corrosion. They are cheaper than the bronze alloys and can be forged at a red heat.

Metallurgical Uses. The widest and most important use of aluminium is probably still in the purification and improvement of iron and steel, and the castings thereof. For this purpose it is always added as "ferro-aluminium," an alloy obtained by adding from 5 per cent. to 15 per cent. of aluminium to pure pig iron. Added to low carbon steel up to 0·2 per cent. it increases elastic limit and tensile strength (at the expense of ductility) and gives good castings without blowholes.

Its value in this connection is illustrated by the photographs of steel castings reproduced in **9** and **10**. In both cases A is the same metal as B, but has had aluminium added to it before casting, 0·1 per cent. in the case of **9**, and 0·5 per cent. in the other case.

By adding from 0·05 per cent. to 0·1 per cent. of aluminium to molten wrought iron a very fluid melt is obtained without the superheating which is ordinarily necessary to cast wrought iron. Castings so produced are called "mitis" castings. They are tougher than malleable iron castings.

though not quite so uniform, and are almost entirely free from blowholes. In fact, mitis castings are objects cast in low-carbon steel, yet having all desirable properties of wrought iron. None of the added aluminium remains in the casting. Its office is simply that of reducing the skin of oxide which prevents the wrought iron from becoming fluid and of preventing the formation of blowholes by keeping the metal fluid long enough to enable all the occluded and dissolved gases to escape.

In the case of cast iron somewhat similar results are produced but for different reasons. Most of the aluminium remains in the finished product because there is no oxide to reduce, its presence being prevented by the considerable quantities of carbon present. The fluidity of the melt is hardly affected. The practical results are that cleaner, more solid, softer castings are obtained with a considerable deduction in the percentage of defective castings.

Non-technical Uses. Of these the largest at present is probably as culinary utensils where its lightness, toughness, non-poisonous, non-rusting, and hard-wearing properties would, but for its cost, have long ago given it that supremacy which is a mere matter of time. An important property in this connection is its high heat-conductivity, which makes cooking in aluminium vessels a speedy matter and scorching almost impossible. A reproduction [11] of a photograph shows several of the more commonly used aluminium saucepans and stewpans, made, without seam, by stamping or casting. None of them weighs more than ½ oz. over the pound (capacity 3 to 4 pints), and the cast-iron handles represent a fair proportion of this weight. In the case of the camp saucepan, with frying-pan lid, the handle weighs 4 oz.

Great hopes were raised at first of the use of aluminium in building and general construction, but the great depreciation in strength which it suffers as the temperature rises, definitely put it out of this field. In military and naval personal and camp equipments aluminium finds an increasing use.

Aluminium for electrical conductors has been rejected by the British Post Office because of the difficulty of making joints, the indefinite and permanent elongation, and, in the case of the bronze, of deterioration. Its low melting point renders the danger of its fusing considerably if the current it is carrying be much increased. It is, however, used for about 500 miles of power conductors in the United States. Whenever it is less than twice the price of copper it is, for conductors, relatively cheaper.

It is successfully used in lithography in place of the heavy, fragile, scarce and variable Solenhofen stone. Its use renders quick printing on rotary machines possible.

Its incorrodibility and innocuousness render it of considerable use in surgery and dental mechanics. It is considerably used in scientific instruments, particularly where the inertia of a heavy moving part has to be avoided. Owing to its comparative freedom from chemical action it is used in many forms of chemical apparatus.

In the form of powder it makes an excellent flashlight, for, in the finely divided form, aluminium burns very readily. The powder is also used with ferric oxide, as "thermit," in the Goldschmidt process, for reducing refractory metallic oxides, and for welding rails, etc.

Aluminium is also largely used in motor-car building, in petrol motor-engines, in aerostatic apparatus and machines, and in a host of smaller miscellaneous articles of everyday use, besides the particular uses referred to above, either for its lightness or its decorative effects. In general it is being increasingly used wherever lightness is synonymous with economy.

Aluminium Salts. Alum and the aluminates are much used in the industries. Alum, in commerce, is the term applied to a double sulphate of aluminium with a base such as potassium, sodium or ammonium. Aluminium salts are the chief mordants used in textile dyeing to fix the dyestuff in the fibre and to modify the colour or shade. Alum is being displaced by the pure sulphate, from which all other aluminium mordants are prepared.

When solutions of basic aluminium sulphates are boiled, a still more basic and insoluble salt is thrown down, especially in the presence of textile fibres. The basic acetates and sulpho-acetates ("red mordants") are used in cotton printing.

Aluminium sulphates are used for the base in "lake" pigments, and are added to Prussian blue and other colours to improve the painting quality. They are also used in the tawing processes of preparing skins for boot and glove making, and in preparing glue for paper-glazing.

In plaster-making, alum is used to increase the hardness. Heated plaster is plunged in an 8 per cent. solution and calcined. When mixed with water, alumed plasters set more slowly but much harder than ordinary plasters, the hardness resembling that of marble.

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Continued

Continued from page 5904

HORIZONTAL AND BAND-SAWS

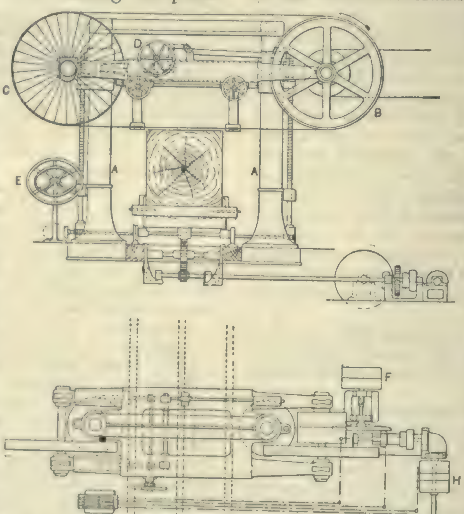
Horizontal Reciprocating Saws. Horizontal and Vertical Band-saws. Loading Appliances

By FRED HORNER

WE may now leave the vertical reciprocating saws, and consider those of horizontal type, which are confined to one pattern, employing either one or two blades. They are used for cutting up hard and expensive woods, and though not so rapid in action as the frame saws they possess some advantages.

A very thin saw may be employed, which wastes a minimum of wood in sawdust, and the power consumed by the machine is small. A very important point is that the boards being sawn but one at a time, the sawyer may examine the timber, and alter the cut for any one board in order to avoid bad places concealed inside. The *figuring* of the timber may also be watched when cutting up for wainscotting or cabinet work. In a frame saw there is no chance to do anything of this kind, because all the blades are set, and must complete the division of the log simultaneously. The horizontal saw does not need a very high grade of skilled labour to operate it and to sharpen and set the saws. It is therefore suitable for mills turning out a moderate quantity of work in valuable woods.

A 36-in horizontal *board-cutter* (as these machines are called) is shown by elevation, plan, and end view in 21 (W. B. Haigh & Co. Ltd.). It will be noted that there is a superficial resemblance to a metal-planing machine. The framing comprises a bed-plate supporting two standards, on the front faces of which a saddle, A, may be adjusted up and down by screws, operated by a hand wheel and bevel gears, or through a belt-pulley. The saw-blade, B, is strained between the extremities of a light steel frame sliding in guides on the saddle, A, the blade being passed through two wood-packed guides, seen inside and below the saddle, these coming close up to the log. A long connecting rod, C, is coupled with a pivoted joint to the end of the saw-frame, and embraces the pin of a bent crank at the other, the crank being turned by a belt pulley, which, together with another, is made as a heavy flywheel. The crank throw is 14 in. The *log table*, D, travelling by rollers upon vee-shaped rails, is racked along through the medium of a set of gears which derive their motion in the first place from the stepped cones at E, driving thence a worm, worm-wheel, and rack pinion. High-speed movements, in either direction, can be given to the table by open and crossed belts on the pulleys, F, connected to the shaft of the table pinion. The table, which is made in any length required, has dogs at its edges, set inwards by screws, to grip the log and prevent it from rolling about.



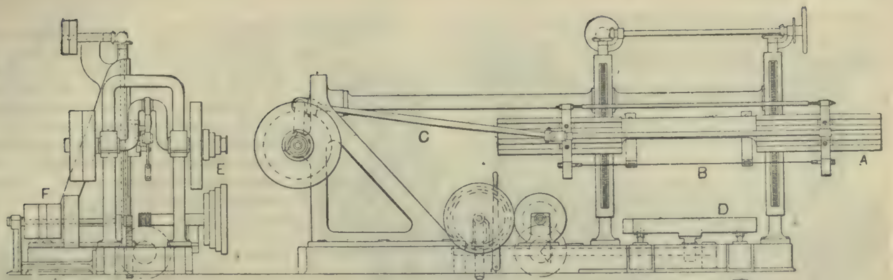
20. HORIZONTAL BAND-SAW

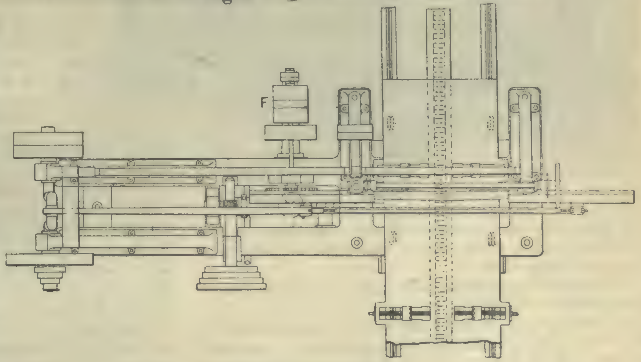
Figure 22 gives a good idea of the general appearance of a saw-frame, with single blade, one of Messrs. Robinson's designs. The cross-rail is adjustable on the pillars by hand or by power, and a graduated scale, recessed into one pillar, enables the sawyer to see the depth of cut in the log at a glance, and to make his adjustments accordingly. The crank-shaft, which is balanced, lies between the sloping standards to the right, and, with its bearings, is adjustable up and down the sloped guides, to keep the connecting rod in a central position relative to the saddle, as the latter is set high or low to suit the cut. The log carriage, a short portion of which is seen in the photograph, is fed by variable friction gearing, and returned at a high speed, all the controlling levers being brought to one place for convenience of operation.

It will be noted that the outlying standard for carrying the driving crank in these machines necessitates devoting a good deal of space in the mill; this somewhat objectionable feature is done away with in one design by bringing the crank-shaft pillar close up to the saddle, and attaching the connecting rod to the far end of the saw-frame. Machines of double type have two blades, each in its sliding frame on front and back of the saddle, one frame having vertical adjustment to alter the height of its blade relative to the other blade. With two blades in action, the output is considerably increased. The saw-frames slide in opposite directions, and are driven from double-throw cranks set at opposite centres.

A practice that is rather common on the Continent is that of standing the driving crank bearings upon a separate brick or cast-iron pedestal, but it is better to tie these bearings to the frame, as seen in the illustrations, to secure steady working. As the saws in the classes of machines described cut in both directions, the feed is continuous, not intermittent. The speeds of horizontal saws average 1,000 ft. per minute, and the pulleys make from 160 to 250 revolutions per minute, according to the size of the log. Rates of feed lie between a few inches and 5 ft. per minute. The tables are usually made about 24 ft. in length.

Band-saws. All the reciprocating saw machines which have been described suffer from one





21. HORIZONTAL BOARD-CUTTER

defect—slowness of cutting. There are two classes of saws which work at a far greater rate, the band and the circular. The former especially is entering into rivalry with the frame-saws, and in many cases ousting them from their position in the mill as log converting machines. It is claimed by some makers of band-mills that one such machine will do the work of three log frames, or twelve horizontal reciprocating machines, a fact due to the enormous cutting capacity of the saw, a steel ribbon having teeth running at a rate of 7,000 ft. per minute. The feed is correspondingly increased, ranging from 5 ft. up to 80 ft. per minute. A subsidiary advantage also gained by using band-saws is that, the blades being very thin (from 16 to 19 gauge, B.W.G.), the waste of wood in the kerf (say $\frac{1}{16}$ in. wide) is greatly lessened by comparison with the thicker frame-saws; when dealing with costly timbers this matter cannot be ignored, since the difference in width of kerf will be sufficient on a few cuts to save a whole board, instead of throwing it away in the form of dust. A skilled operator is required to work a band-saw machine properly, and get the most out of it, and the sharpening and setting of the saws must be done efficiently, but there is no great difficulty in this.

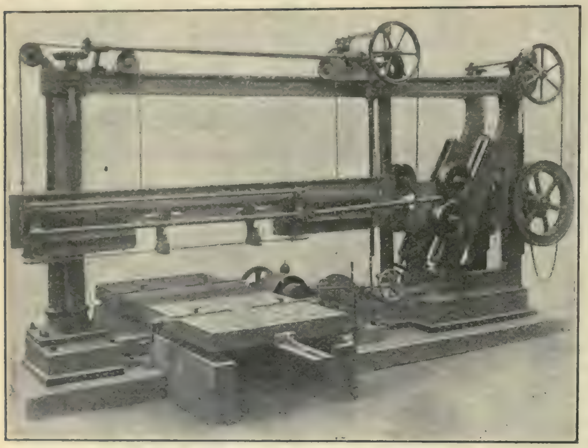
Horizontal Band-saws. Band-saws are constructed in two types, horizontal and vertical, the latter being used far more in America than here. A horizontal machine by Messrs W. B. Haigh & Co., Ltd., illustrated in front view and plan by 20, embodies the principal features found in such saws. Two circular pillars, AA, bolted to a bed plate, receive sockets supporting a cross-rail, in the ends of which the bearings for the wheels, B, C, are held in pivots, to let the wheels align exactly with the saw. The pulley B is driven from fast and loose pulleys on its shaft, and it is of heavier construction than the other pulley, C, as the latter is an idler, driven only by the saw. The blade passes through *guides* seen adjacent to the log. Tension is given to the saw by pushing out the pulley C in a socket bearing by means of the hand wheel D, operating a worm gear and screw. A balance weight arrangement (seen above the cross-rail, adjacent to D) maintains an even tension on the blade when running by keeping a pressure on the pulley socket. The entire affair is raised or lowered on the columns, AA, by two screws, worked from worms turned by a horizontal shaft driven through bevel gears from a hand wheel, E. An indicator shows the attendant how thick a board will be cut.

The log carriage, fitted with screw dogs, and travelling upon a V and a flat rail, is actuated by rack and pinion from the belt-pulleys at F, driving a friction disc, which rotates a roller at varying rates and communicates by belt-pulleys across to a gear turning the rack pinion shaft, G. A high speed in either direction is obtained from open and crossed belts on the pulleys H, thrown into gear through bevels, and a claw clutch with G. A set of four levers at the stand, J, connect by rods to the three belt-shippers and the claw clutch, so that the sawyer has complete control.

Figure 23 shows a machine by Messrs. Robinson, with a log in position, and the *feed works* shown by the breaking away of the floor. The attendant's stand in front of the left-hand pulley is also clearly shown. The pulleys are 5 ft. in diameter. The friction feed gear gives any speed up to 60 ft. per minute, and quick movements of the carriage are obtained independently.

A photograph taken while the machine was running is reproduced in 24, showing one of Messrs. Ransome's saws, driven by an electric motor mounted directly upon the right-hand pulley spindle. The sawyer is controlling the speed of the log as he watches the cut. Some interesting examples of the output of band-saws are given by the firm, the result of three hours' work. One man worked the machine, while two labourers removed the boards, and helped to fix the logs in position.

An elm log, averaging 33 in. diameter, and 14 ft. 4 in. long, cut into 27-in. boards, and two slabs in 40 minutes. Whitewood log, $28\frac{1}{2}$ in. square, by 16 ft. 5 in. long, cut into 51 $\frac{1}{2}$-in. boards in 60 minutes. Mahogany log, 15 in. square, by 20 ft. $7\frac{1}{2}$ in. long, cut into 19 boards of differing thicknesses. Wainscot log, 12 in. by 18 in. by 13 ft. 7 in. long,



22. HORIZONTAL BOARD CUTTER

cut into 17 1-in. boards. Kauri pine log, 18 in. square by 15ft. 2 in. long. Six ½-in. boards only were cut from this.

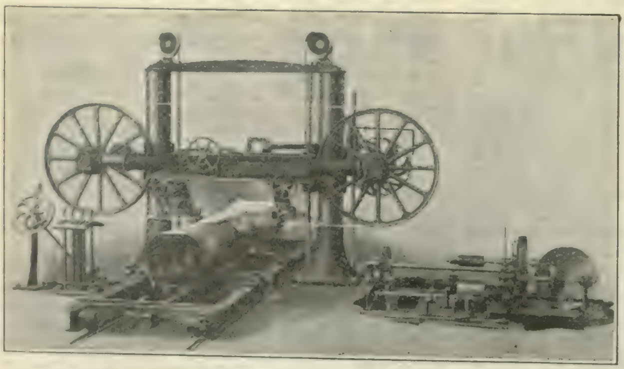
The total superficial feet sawn in three hours amounted to 3,749.

A special type of log band-saw is constructed for the use of shipbuilders, who require to cut out ships' timbers of considerable length, having curves and bevels. The two pulleys are arranged to rise and fall independently, so that the blade can be set to an angle, and gradually lowered or raised to follow a curve marked upon the face of the log. The carriage is of great length, usually 60 ft.

The saws which we have described and illustrated are of a type with the saw completely above the floor and the table. There is one design, made by Messrs. Kirchner, of Leipzig, which differs from the ordinary style, in that the pulleys are set low, and the blade passes beneath the table, cutting with its upper portion. The cross-rail is thus dispensed with, and the machine occupies less head room, but excavation is necessary to take the bottom portions, a feature which is done away with in the ordinary machines.

Vertical Band-saws. The *vertical* log band-saws are rather less expensive to construct than the horizontal types, and they occupy less width in the mill, while they are capable of breaking down the largest sizes of logs. An objection to the design is that the lower pulley is partly or wholly buried under the floor of the mill. At the same time, very large pulleys can be used, as much as 9 ft. in diameter in the biggest machines, with wide and powerful blades. The Americans favour these vertical band-mills, to the exclusion of horizontal types. The difference in the attitude of the saw, lying as it does vertically, necessitates presenting the log sideways, and as the pulleys are fixed, the log must be fed inwards for each cut. Figure **25** shows a vertical band-mill, by Messrs. Ransome, in which driving is effected by an electric motor, seen to the right, coupled to the spindle of the lower pulley, which is of heavy construction. The top pulley is built lightly, and its spindle is supported in swivel bearings, adjustable up or down, and provided with a weight to give sufficient tension to the blade. Hard-wood guides are placed to keep the saw running straight, above and below the log. One of the objections to the early band-mills was that the truth of cut could not be depended upon, but with improved methods of hanging the saws, and constructing the framings and bearings, together with the provisions of proper guides, this trouble has disappeared. Difficulty is experienced only if an attempt is made to force the log along too fast for the saw to cut properly.

The feed of the log carriage is effected through friction wheels, operating a rack and pinion. The special feature, however, of the carriage [**26**] is the method of gripping and feeding up the log to the saw. The term *dog carriage* is applied, and in America the feeding device is called the *set works.* A number of headstocks are mounted on lateral slides bolted to the longitudinal beams of the carriage. The log is gripped between top and bottom dogs or clips attached to the vertical faces of the headstocks, the dogs being locked by the action of weighted cam levers. All the headstocks are fed up to the saw simultaneously through screws and shafting operated from a ratchet wheel, which is manipulated by the attendant with a lever, on both forward and backward movements of the lever. The amount of set-in may be gauged exactly, to give a definite depth of cut. The headstocks are drawn backwards rapidly by means of the hand wheel seen at the foreground, working bevel gears connecting to the feed screws. An arrangement is fitted by which the log may be moved backwards, or *offset*, after each cut, sufficiently to keep the back of the saw from catching in the sawn face.

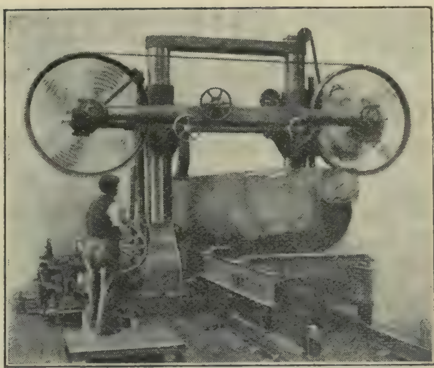


23. HORIZONTAL LOG BAND-SAW

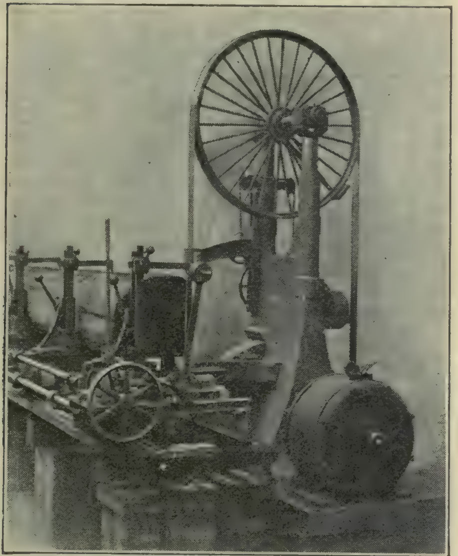
Feeding Devices. Two modes of feeding other than by rack and pinion are employed largely in the States. *Rope feed*, suitable for very long logs, embodies a friction drive, or a separate steam engine to wind an endless wire rope around a drum, and pull the carriage in one direction or the other, for cut and quick return. Direct-acting

steam feeds include a long steam cylinder lying below the carriage, with a piston-rod connected to it, so that as the piston is driven in either direction the carriage is drawn along, the rate of feed being variable by the sawyer admitting more or less steam by a controlling valve. The cylinder is built up in any desired length by sections from 4 ft. to 8 ft. long, by 7 in. to 9 in. bore. A combination of a steam cylinder and a rope passing over pulleys is also used, in principle like the mechanism employed on hydraulic cranes and lifts, with multiplying pulleys.

Loading Appliances. A special class of appliances is employed for loading logs on to the carriages from a sloping *skid* upon which the logs are stored, lying parallel with the carriage. The *log turner* is a kind of friction winch, operating a chain, at the end of which there is a hook, to engage



24. HORIZONTAL LOG BAND-SAW IN OPERATION



25. VERTICAL LOG BAND-SAW

in the log, and roll into position on the carriage, after which it may be turned and adjusted. The *log loader* comprises a steam cylinder fitted below the bottom of the log skid, and actuating arms which release a log and allow it to roll on to the carriage of the saw. A foot pedal operates the steam valve. The *steam nigger* is the quickest means of handling; it consists of a long vertical *arm*, to which are attached hooked spikes. The arm is moved up and down, or canted by two steam cylinders of direct-acting type, and the spikes may be made to catch in a log, pull it from the skid, roll it on to the dog carriage, and further turn it into any position most convenient for sawing. The skids are supplied with logs from a haul-up slipway, mentioned previously in connection with the lay-out of sawmills. There is a good deal of machinery for rapid handling employed in America that is hardly represented in British sawmills. In addition to the loading appliances just described, centre decks are fitted to the haul-ups, for rolling the logs to one side or the other down the slope of the skid, from which they are taken off by one or other of the machines mentioned. The decks are worked from vertical steam cylinders, to the pistons of which arms are pivoted, and canted over as desired to press against the logs.

Live rolls, consisting of a train of rollers positively driven by bevel gears, are useful for transferring material from the band-mill to the re-saws, and they save a great amount of time which would be occupied by hauling about by hand and cranes. The timber is transferred to or from the live rolls by mechanism which avoids handling on the part of the men; the lateral motion is produced by an endless pair of chains, which are raised into contact with the lumber when desired, or by spiral rolls making contact underneath.

Sawdust conveyors are used to transport the dust and refuse from the mill to the boiler-room; they are ran by an endless chain driven from sprockets, the chain carrying an open trough with sloping sides.

Circular saws, for breaking down, are treated in the next section of this course, together with the various lighter re-sawing machines.

Continued

26. LOG CARRIAGE

Group 3 LOGIC 1 Following SOCIOLOGY from page 5817	THE SCIENCE OF REASONING — Logic, the Business of Thinking. How to Find Out the Truth. Francis Bacon and John Stuart Mill. The Place of Facts and the Laws of Argument

Following SOCIOLOGY from page 5817

THE SCIENCE OF REASONING

Logic, the Business of Thinking. How to Find Out the Truth. Francis Bacon and John Stuart Mill. The Place of Facts and the Laws of Argument

By Dr. C. W. SALEEBY

"IT has consistently been the object of the SELF-EDUCATOR," the reader will say, "to stimulate us to reason and to think. Whatever the subject of the course, whether animals or metals, or ideas or what, we have constantly been encountering something which, as the French say, gives furiously to think. Now, at this late stage in the proceedings, after some of the most important of these subjects have run, or nearly run, their course, we are asked to consider the methods and principles of correct thinking. Surely this is a little late in the day. Would it not have been more *logical* to have determined the principles of thinking first and then, properly equipped, to have attacked the problems of nature and art?"

Logic the First and Last of the Sciences. This, of course, is fair criticism, and it is to be hoped that every reader not already familiar with it will find it occur to him. From one point of view, logic is unquestionably the fundamental science. If it were possible, as it is certainly not, to arrange the sciences in a form of classification, having a beginning and an end, we could not very well question the right of logic to the premier place. It would be much better, however, to arrange the names of the sciences in a circle, and then we should find that logic was alike first and last. First, because its principles are employed in all the other sciences as well as in itself; last, because it is from all the other sciences that those principles are inferred.

Logically, then—as that word is used—we should have begun with logic. Practically, that course would have ended in failure. The old way of teaching a foreign language to children was precisely analogous to the plan which we have not followed. The teacher began with the grammar of the subject and went on to its syntax. This was the surest way in which to make the language uninteresting, and whilst it looked scientific, it was really antiscientific; since, instead of giving the student reasons for the rules, or explaining the manner in which they have been arrived at, the teacher simply stated these rules as dogmatic truths to be accepted blindfold.

Logic Must Have the Facts. It is now recognised, on the contrary, that though its grammar is fundamental to every language, just as its logic is fundamental to every science, the best fashion in which to learn a language—at any rate, for a child—is to begin with the facts and to obtain the rules afterwards.

Now, this is exactly what has been the actual history of grammar and of logic. Languages have not been built from their grammar upwards, so to speak; the recognition of grammar has always come last. The language has been perfectly spoken and written by men who never concerned themselves with the existence of its theory or grammar at all; then, afterwards, when there were multitudes of facts—facts of vocabulary and facts of usage—grammarians came, and from the facts inferred grammar by a particular logical process which is the most important of all logical processes, and which we must afterwards study.

Thus, also, logic is the last of the sciences. No science has been built from its logic upwards. The prime cause of the failure of logical systems in time past has been their prematurity. There were not enough facts from which to infer. This is why Aristotle, a consummate genius, the father of the science of logic, made what is from some points of view such a splendid failure. In his day there were not enough facts from which to infer a system of logic. Just as a grammar can only be established after a language has become a living thing, so a system of logic can only be established after science has become a living thing. For all this there is, as we shall see, a logical reason.

The Value of Logic in Life. And here we must meet another critic. Homer—or the other man of the same name—wrote divine poetry and knew no textbook grammar. Galileo founded a new science, yet scarcely concerned himself at all with the principles of reasoning. These things are therefore superfluous. A little common-sense will keep one straight in writing and in thinking too. Let grammar be left to the grammarians and logic to the logicians, and let us get on to less idle matters.

This also is a fair criticism, but it can be met. It does not follow that the man of letters is not the better for grammar, nor the man of science for logic. Whatever the history of literature may be, the history of science assuredly teaches us that the most unfortunate errors have constantly been made by the most acute and thoughtful observers just because of their logical insufficiency, and that logic is pre-eminent as a means of economy in science, saving much time and making the most of effort. It is, unfortunately, the fact that at the present time the young student of science is not equipped with any form of training whatever in the principles of scientific thinking—which are, of course, the principles of all valid thinking. For reasons which are obscure, if not incomprehensible, logic is not conceived at our universities as having any particular relation to science. It is usually part of the Arts course, and is often bound up with metaphysics. Here, however, we must endeavour to make a step onwards and realise that logic is the first and last of the sciences—certainly not to be neglected by the scientific student, to whom it

is a thousandfold more important than to the student of letters.

Scientific Reasoning. Since the proper province of logic has been variously conceived by various thinkers, we must not be too dogmatic in our attempt to define it, especially as language is a fluid thing, meaning different things at different times. The great modern logician, beyond all dispute, is John Stuart Mill. He approves of the definition of logic as the *science and art of reasoning*—but nowadays we use art in a more restricted sense, and the distinction which he draws between the two terms may be ignored. Furthermore, we must definitely use the word reasoning in a wider sense than was at one time admitted. At one time a man was said to reason only when he drew a particular conclusion from a general proposition—as "Man is mortal; I am a man and therefore must die." This, of course, is one of the typical rational processes, but there is no adequate reason why we should deny the term reasoning to the converse process —thus, "All the men who have ever lived have died, and therefore man is mortal."

Without further parley, then, let us discuss the last of these processes and contrast it with the other. Various pairs of terms are used in order to contrast them. Reasoning from the general to the particular, and reasoning from the particular to the general, are known respectively as *a priori* reasoning and *a posteriori* reasoning, or as deduction and induction. Let us use the word *inference* indifferently, but do not let us say "deduce" when we are describing a process not of deduction but induction. These two terms have specialised meanings which ought to be recognised. The method of science is induction, and the first question which we may ask ourselves is as to the history of the recognition of this truth.

The Dogmas of the Church. It is one of the great facts of the history of thought that the value of induction has been late of recognition. Aristotle paid it but little attention; his logic was deductive logic. Given a general proposition —he asked himself—what is the proper fashion in which to deduce from it, what is the manner in which we ascertain the other propositions, less general, which are implied or involved in the first proposition, and which necessarily flow from it? For ages this logic of Aristotle remained hidden along with the rest of his work. Plato was accepted by the Church, and the Church was supreme. In the thirteenth century, however, that mighty thinker, St. Thomas Aquinas, reinstated Aristotle, who thus came to be accepted of the Church, and whose logical methods were admirably suited to the needs of the Church at that time.

From the point of view of those who accepted the mediæval Church as a final authority on all things, whether of heaven or earth, there was evidently no need for any but a deductive logic. The idea of questioning Nature never arose. From the authority of the Church there were derived various comprehensive propositions. In order to ascertain the truth upon any subject, therefore, it was merely necessary to reason correctly from those infallibly true propositions. Given true dogmas of universal applicability, and given absolutely sound methods of reasoning deductively, or *a priori*, from them—the truth upon all subjects was at anyone's disposal.

Francis Bacon. But, as everyone knows, disaster followed. To silence Galileo was not to place the earth in the centre of the Universe, and the authority of the Church *in matters of science* found itself in difficulties from which it has never since been extricated. That amazing genius, Francis Bacon (1561 to 1626), dedicated to the King in 1620 his great work called the "Novum Organum." Despite its many defects and faults, this great work must remain a classic for all time. Every pioneer has faults. Nothing is easier or more impudent than, standing on the shoulders of Aristotle or Bacon or Spencer, to declare them short-sighted. Bacon's own knowledge of science was not really adequate for his purpose. Harvey said "The Lord Chancellor writes on science like a Lord Chancellor." Bacon declared that his methods would level men's wits—"for our method of Discovering the Sciences merely levels men's wits and leaves but little to their superiority, since it achieves everything by the most certain Rules and Demonstrations." Some three centuries have elapsed, and we may confidently say that the difference between little men and big men is as conspicuous—and as humbling for us little ones—as ever it was. Bacon under-estimated the value of hypothesis in science—there was to be no tincture of any method but his method. And what is this?

The Logician's Only Hope is in Induction. Man, the servant and interpreter of Nature ("Naturae minister ac interpres"), depends for his knowledge of truth upon the questioning of Nature, and especially upon rightly putting the question to her. We must not dogmatise until we investigate. "They who have presumed to dogmatise on Nature, as on some well-investigated subject, either from self-conceit or arrogance, and in the professional style, have inflicted the greatest injury on Philosophy and Learning."

The better method was not to dispute upon the very point of the possibility of anything being known, but to put it to the test of experience. Bacon goes on to say that the art of logic, employed "after the mind has become prepossessed with corrupted doctrines, and filled with the vainest idols—has tended more to confirm Errors than to disclose Truth." Instead of the "Anticipation of Nature"—so-called "as being rash and premature"—Bacon seeks the "Interpretation of Nature." "The present system of Logic is useless for the discovery of the Sciences—it forces Assent, therefore, and not things." This is a never-to-be-forgotten distinction. If our notions "be confused and carelessly abstracted from things, there is no solidity in the superstructure." Our only hope, then, is in genuine Induction.

There are two means by which induction may be employed. Bacon describes them and condemns the first. The three paragraphs in which he does so are far too admirable and

far too pertinent to be mutilated. Here they are.

Bacon's "Two Ways of Finding Truth." "There are and can exist but two ways of investigating and discovering truth. The one hurries on rapidly from the senses and particulars to the most general Axioms; and from them as principles and their supposed indisputable truth, derives and discovers the intermediate Axioms. This is the way now in use. The other constructs its Axioms from the senses and particulars, by ascending continually and gradually, till it finally arrives at the most general Axioms, which is the true but unattempted way.

"The Understanding when left to itself [the original is "Intellectus sibi permissus"—a famous phrase] proceeds by the same way as that which it would have adopted under the guidance of Logic—namely, the first. For the mind is fond of starting off to generalities, that it may avoid labour, and after dwelling a little on a subject is fatigued by experiment. But these evils are augmented by Logic, for the sake of the ostentation of dispute.

"Each of these two ways begins from the senses and particulars, and ends in the greatest generalities. But they are immeasurably different; for the one merely touches cursorily the limits of experiment and particulars, whilst the other runs duly and regularly through them: the one from the very outset lays down some abstract and useless generalities, the other gradually rises to those principles which are really the most common in Nature."

Where Bacon was Wrong. The only sound method, according to Bacon, is to collect facts, right and left and indiscriminately. So lamentable were the consequences of the neglect of the inductive method in his time that he would not allow even a fragment of any other method to be employed. Nowadays we are able to see, however, that Bacon was wrong. No discovery of any moment has ever been made by the rigid use of his method, and doubtless no such discovery ever will be so made. The discovery described by Darwin in his "Origin of Species" is one of the greatest of all time. For twenty years Darwin collected facts upon which to build his great induction; for twenty years he rightly put the question to Nature—*but* he tells us himself that he opened his first note-book to collect facts *bearing on the hypothesis* of the natural origin of species.

This criticism is noteworthy, but it must not for a moment blind us to the epoch-making character of Bacon's great perception "Anticipations," he says, "are sufficiently powerful in producing unanimity, for if men were all to become even uniformly mad, they might agree tolerably well with each other. Anticipations, again, will be assented to much more readily than Interpretations, because, being inferred from a few instances, and these principally of familiar occurrence, they immediately hit the Understanding and satisfy the imagination; whilst, on the contrary, Interpretations being deduced from various subjects, and these widely dispersed, cannot suddenly strike the understanding; so that in common estimation, they must appear difficult and discordant, and almost like the mysteries of faith. In sciences founded on Opinions and dogmas it is right to make use of Anticipations and Logic—[that is, Logic as understood in Bacon's time, the logic of Aristotle and the school men]—if you wish to force assent rather than things. If all the capacities of all ages should unite and combine and transmit their labours no great progress will be made in learning by *Anticipations;* because the radical errors, and those which occur in the first process of the mind, are not cured by the excellence of subsequent means and remedies."

The Proper Place of Facts. Nowadays Bacon's great argument has triumphantly vindicated itself. The inductive method we now recognise as *the* scientific method. Another term for induction is generalisation, and the great object of science is to generalise. Individual facts have their value, of course, simply as individual facts, just as a brick is worth something as a brick. But the real object of science is to be able to state a vast number of particular or individual facts as one great fact which includes them all. Such a great statement is a generalisation or induction, and its value bears the same relation to any of the individual facts which it expresses that a mighty building bears to any of the bricks of which it is composed.

In the ordinary language both of science and common speech generalisations such as we have described are commonly called *laws.* We speak, for instance, of the law of gravitation or Newton's laws of motion. The term is a good one, and it is a bad one. It is good because it expresses something of the constancy of Nature. It is thoroughly bad because it gives us an entirely wrong notion of the real character of what we call laws of nature. No better illustration can be found than the law of gravitation. Wherever and whenever we examine the behaviour of matter, we find that it exhibits a constant tendency to attract other portions of matter with a force varying definitely according to definite conditions. We notice this, so to speak, of the moon and of the planets and of an apple on the earth, and after we have noticed it on a great many occasions and in a number of different instances, we venture to express these particular facts in a general statement which will include them all. The "law" of gravitation is merely such a general statement or generalisation.

The Danger of a Generalisation. But every generalisation without exception is more comprehensive than the series of particular facts on which it is erected. We may have examined a million cases and found gravitation true, but the generalisation which we have erected upon them presumes to cover not only all the other cases in the present, but all the cases in the past and all in the future. Thus there is something hazardous in induction. If there are a thousand and one facts, and you have framed an induction upon a thousand of them, the remaining one may defeat you; and the facts of Nature are infinitely numerous. We

therefore can never have too many facts upon which to build, and we can never be too modest in the expression of conclusions. Fortunately, there is, however, a means of testing our generalisations, and that is by the use of deductive reasoning, as we shall soon see.

Now, let us observe what is implied in all our generalisations, such as that of gravitation. What is the logic of them? We ascertain a number of facts about matter in certain conditions, and we venture to assert that, therefore, similar phenomena will always be displayed and always have been displayed by matter in similar conditions.

The Stupendous Assumption of Uniformity in Nature. But there is a stupendous assumption here, as the thoughtful reader will immediately see. It is the assumption that Nature is uniform, continuous, consistent, constant; the assumption that causation is universal, and that like causes always produce like effects. This tremendous postulate underlies all our inductive reasoning, and if it be not granted, not a single scientific induction, not a single so-called law of science, need be accepted. The objector may say, "What you assert may be true of all the cases you know; it may, indeed, be true of every case at present and of all cases in the past; but what proof have you that it will be true to-morrow?"

Now, the doctrine that Nature is uniform is not by any means a sort of intuitive truth which the mind has always possessed or has always taken for granted. It has to be acquired by the mind of the child; it has taken countless ages to be acquired by the minds of the greatest thinkers of the race, and it is only nowadays beginning to become common property.

It is immeasurably the greatest of all generalisations—the greatest because it is the most comprehensive and the most significant, and the greatest because the truth of it is assumed in the construction of all other generalisations whatever. But it has a wide base. It rests upon every fact known to experience, and there is no known fact that contradicts it.

Nature Keeps Her Word. It is only with the utmost difficulty that this truth has won its way from department to department of human thought. For centuries after it had been grudgingly admitted as true of inanimate objects its applicability was entirely denied to living things. The notion that it applies to man and his doings as an individual or in society is still repugnant to many who are concerned less to question its truth than to declare that it belittles man and human life—instead of, as we believe, exalting them. But whether true or false, this great doctrine that Nature *keeps her word*, that there is neither chance nor contradiction nor caprice in the cosmos, is the underlying assumption of all scientific generalisations. We shall do well to recognise this ere we generalise at all.

Our insistence upon the importance of the greatest of inductions, and of the recognition of it as an assumption whenever we generalise, leads us to the name of John Stuart Mill, to whom the argument is chiefly due, and a brief account of whom cannot possibly be ignored in any discussion of inductive logic.

John Stuart Mill. Mill was born a century ago, in May, 1806, and died in 1873. He is one of the most conspicuous instances of hereditary genius, his father, James Mill, being a great historian and psychologist. A great deal of Mill's work was controversial against the accepted theology of his time. Much of it, and that extremely important, was political, and some of it ethical; but beyond a doubt the greatest work of him whom Mr. Gladstone called "the Saint of Rationalism" was his "System of Logic," published in 1843. This great work can now be obtained for a very moderate sum, and the reader may be assured that sixty years have not brought it anything but strength. In a previous course we have had occasion to quote from this great work a conspicuous instance of insight and prescience as regards the ultimate character of the elements. This and the "Novum Organum" are no doubt the greatest works yet written upon inductive logic. Mill's tremendous advantage over Bacon may be realised if we remember that Mill was a psychologist, as Bacon was not, and more especially that inductive logic had been practised, and that with the very greatest success, during the two centuries that separated these great works. Between them there appeared no work on logic of any such rank—nor since. The book is very long and not easy reading, but the serious student will be well advised to prefer it to the various renderings of it which have been given by subsequent writers.

A Summary of Mill's "System." Mill demonstrates a number of necessities, which must be taken for granted in an introductory course so brief as this. He shows, for instance, that we must analyse language ere we can make much progress. If we do not examine the real import of names and other words we cannot "examine into the import of propositions . . . . a subject which stands on the very threshold of the science of logic." It follows that, as may have already suggested itself to the reader, the relation between grammar and logic is even closer than our initial analogy between them suggests. Grammar is indeed none other than the logic of language, and most errors in the use of language are errors in logic and fit study for the logician.

Here, however, all that can be done is to direct the reader's attention to one or two of the most remarkable chapters in this book. These are also the most attractive chapters, and will encourage the reader to proceed. He cannot read Chapter VI., "On Propositions Merely Verbal," without feeling that he has made a discovery, and the same is true of Chapter VIII., "On the Subject of Definition." From this the work proceeds to Book II., which deals, comparatively briefly, first of all with inference or reasoning in general, and then with reasoning in the old-fashioned sense of the word—namely, with deduction. Book III. is the longest and much the most important, dealing with induction in a

fashion which is now classical. Here the reader will delight in the chapters on the law of causation, the laws of Nature, Chance, Observation, and Experiment. Book IV. is subsidiary to Book III.; Book V. deals with the fascinating subject of Fallacies, and Book VI. with the logic of the moral sciences, by which now obsolete term Mill means psychology, sociology, the science of character, and their allies.

All Science Begins in Observation. Let us learn from this brief analysis that neither logical process should be regarded as complete without its fellow. We commonly speak of induction or inductive logic as the scientific method, and too great emphasis cannot be laid upon the fact that the beginning of all science is observation. To this experiment may be added, but, of course, experiment is none other than observation under purposely devised conditions. But no science is perfect which uses induction alone, and there are sciences in which induction is almost entirely or entirely absent. Pre-eminently, mathematics is a deductive science, and it has that character of infallibility which distinguishes the products of sound deduction. In mathematics, when certain things are granted, certain other things follow, and inevitably follow. They must be so, if the laws of deduction are to be taken for granted. Given the conditions and assumptions of the geometrician, the three angles of a triangle must be equal to two right angles. There is not the slightest need to measure them in any particular case or series of cases. The fact must be so.

How the Telescope Upset the "Logicians." Now, would it not be pleasant if only all the other sciences could share this delightful privilege of mathematics? The old opinion, indeed the common opinion before Bacon, was that they could. It was not necessary to look upon the sky; there must be seven planets because there were seven virtues and seven deadly sins, and because seven was the perfect number. When Galileo asked one of his colleagues at Pisa to look through his newly-invented telescope at the newly-discovered moons of Jupiter, the worthy man refused. He knew *a priori*, or by deductive logic, that Jupiter could have no moons, any more than the sun, being perfect, could have spots—which Galileo also discovered. The "a priorist" was wrong, and will be a byword to all succeeding time. But it is obvious that, as Bacon pointed out, the method is an easy and convenient one. It is not only easy and convenient, but it leads to the truth in mathematics. And the question arises whether there is not some place for it in the other sciences.

Deduction *has* such a place in science generally, and we may even say that no scientific conclusion is perfectly established until it can be reached alike by induction and deduction, alike *a posteriori* and *a priori*, alike by direct observation and by pure reasoning.

How Newton "Reasoned Out" Gravitation. Let us take a never-to-be-forgotten instance. Working upon the laborious observations of Keeper, Newton made a great induction or generalisation—that the motions of heavenly bodies are determined by a force called gravitation. That induction could not be regarded as secure, any more than any other induction can, until it had been used as a basis or starting-point or assumption for the process of deduction, and until observation had shown that such deductions led to the truth.

Neither induction nor deduction can stand alone, and the results of each afford great service to the other. Starting with the law of gravitation as a truth—its origin, whether by induction or by universal consent or by a necessity of the mind, being for the moment immaterial—it must follow by deductive reasoning that certain peculiar movements on the part of the planet Uranus must be due to another planet of a certain size and distance situated still further from the sun. This was the deductive conclusion. If the truth of the law of gravitation be taken for granted, and if all other explanations of the irregularities of the path of Uranus be excluded—this difficulty of excluding all other possibilities being the cardinal difficulty of deduction in practice—then there must be such a planet, and there is no more need to look for it with the telescope than the old astronomer thought there was need to look through Galileo's. But men knew how dangerous *a priori* reasoning is, and they therefore put the deduction to the test of observation, with the result which all the world knows.

"If This Is So, That Must Be So." Not only does the discovery of Neptune serve as an observation, confirming the processes of deductive reasoning from the law of gravitation, but evidently it furnishes new and potent strength to that great induction itself. And this is the test of every induction—that when used as a starting-point for deduction it shall lead to conclusions capable of independent confirmation. The common-sense man perfectly well recognises this great process. The reader will recognise his recognition of the process and of its importance in such an imaginary conversation as this, which might be heard at any street corner: "Oh, you think that's the way of it, do you? All right then; if that's so, then that other affair must be as I said it would. Come along, and we'll see if you are right." In other words, our friend proposes to test an inductive conclusion by the consonance with fact of the deductions from it.

Continued

THE WORKPLACES OF BRITAIN

Industrial Geography of Great Britain. British Trade Returns. Great Britain as a Carrier. Analysis of Colonial and Foreign Trade. The Trade of the Ports

Continued from page 5826

By Dr. A. J. HERBERTSON and F. D. HERBERTSON

BRITAIN has passed through many phases of economic development. In early times it was visited for its tin and copper. During the Roman occupation agriculture was developed in the south-eastern lowlands of Great Britain. In the Middle Ages it was noted for its wool, which was transported to Flanders, to be manufactured there. Gradually manufactures grew in England itself, and in the eighteenth century the use of coal in smelting and of steam power in manufacture altered the economic conditions, and Britain was the first country to develop a great manufacturing industry. The effect of steam power was felt in transport as well as in manufactures, and in railways and steam navigation Britain led the way.

This advantage is now gradually passing away, and Britain depends for success largely on its inherited trade relations, an educated manufacturing population with inherited interests and skill, an immense accumulation of capital, and upon great natural resources, of which coal has hitherto been the most important. This coal is exported to nearly all parts of the world, and is one of the sources of our present supremacy as a commercial country, permitting us to carry cargo both ways. How far it is desirable to exhaust our coal too rapidly is a difficult political question.

In briefly analysing the commercial geography of Britain, we must leave out of account the social aspects of the question and confine ourselves to the actual mineral and manufacturing products, on which our commercial importance so largely depends, and on the trade relations of the country.

Geography of British Industries. The economic aspects of different natural regions of Britain have been fully described in previous parts. All that is necessary here is to briefly recapitulate, under the headings of different industries, the chief centres at which they are carried on.

The *mineral resources* and *engineering industries* have already been described on pages 987 and 5306. Coal and iron are the most important. Our coal supplies are discussed on page 5302. Already much of the best iron ore is used, and much is imported.

The engineering industries are the most widely distributed. In special centres they take special forms. The ironworks of Clyde, Northumberland, Durham, and Barrow districts are the cause of the great shipbuilding activities in these districts, while Belfast is admirably situated for obtaining coal and iron cheaply from Scotland and North-western England. Locomotives are also manufactured in the first two districts and around Manchester, as well as at the great engineering works of the leading railways at convenient centres on big railway systems which are not directly determined by mineral resources, such as Crewe, Swindon, Derby, etc. Similarly, vessels for the Navy are built on the Thames, at Portsmouth, Devonport, and Pembroke, where it is desirable, for strategical reasons, to have skilled workmen and all appliances for naval construction. Hardware and most classes of iron and steel work are made in the Black Country, round Birmingham and Wolverhampton. Cutlery, armour plates, and other steel articles, are made in Sheffield, Rotherham, and the Don district, and steel in the Tyne and Central Scotland districts.

Textile Industries. *Cotton* is the most important textile, and its spinning and manufacture into cloth are mainly Lancashire industries. Oldham, Rochdale, Bury, Bolton, Stockport, Stalybridge, Ashton, Preston, Burnley, Accrington, Blackburn, and many other places are the centres of greatest activity in South Lancashire and the adjacent parts of Cheshire, which form a vast aggregate of population, of which Manchester is the market, with Liverpool as its port. Cotton thread, spun in Paisley, is the only important use of cotton in Scotland. Lace is made at Nottingham. The bleaching, dyeing, and colour-printing operations are carried on at most of the cotton centres, and round Alexandria, in Dumbartonshire.

Woollen manufacturing is the oldest textile trade in Britain, and, as has been explained on pages 1272 and 5120, it flourishes all over the United Kingdom, but more particularly in the valleys of the West Riding of Yorkshire, and of the Bristol Avon, and Stroud Water, with good water supply, and near iron and coal fields; in the Tweed basin, which is not very distant from coalfields. The chief centres are Leeds, Bradford, Halifax, Huddersfield, Batley, Dewsbury, Wakefield, and Barnsley, in Yorkshire; Bradford-on-Avon, Stroud, in the West of England; and Hawick, Galashiels, and Selkirk, in the South of Scotland. Blankets are made at Witney, in Oxfordshire, and carpets at Kidderminster and Wilton, and hosiery at Leicester.

Other Textiles and Minor Industries. *Linen* manufactures are concentrated in Eastern Ulster, where flax is grown, especially at Belfast, Lurgan, Lisburn, and Portadown. Dunfermline, in Fife, makes fine linens.

Jute manufacturing is important in Dundee, where jute is brought in sailing vessels from Calcutta.

Silk is not manufactured so much as it might be, but it is of some importance in such centres as Macclesfield and Derby.

Brickmaking is common on all the clay areas, and *quarrying* where good stone is abundant.

Pottery is made especially in North Staffordshire, round Stoke-on-Trent, and Newcastle-under-Lyme, in Worcestershire, and at Kilmarnock, in Scotland.

Brewing and *distilling* are practised all over the country. The three capitals, and Burton-on-Trent, are noted for brewing ales and stouts, while distilling is important in Edinburgh, Dublin, and at many centres in Scotland and Ireland.

British Trade Returns. The student should procure and study carefully the December number of the "Accounts Relating to Trade and Navigation," usually published early in the new year. This gives not merely the trade for December, but that for the past year, with returns for two previous years for comparison. This may be supplemented by the "Annual Statement of the Trade of the

THE HOME EXPORTS AND THE TOTAL IMPORTS OF THE BRITISH ISLES

ARTICLES.	Exports of British and Irish Produce, &c. (Value F.O.B.). 1904.	1905.	1906.	Increase (+) or Decrease (−) in 1906 compared with 1904.	Imports (Value C.I.F.). 1904.	1905.	1906.	Increase (+) or Decrease (−) in 1906 compared with 1904.
I.—FOOD, DRINK, AND TOBACCO :	£	£	£	£	£	£	£	£
Grain and Flour	1,804,503	2,768,937	2,582,092	+ 777,589	68,796,597	69,200,285	67,879,948	− 916,649
Meat, including Animals for food	745,197	924,365	1,339,686	+ 594,489	48,666,315	49,431,748	52,044,106	+ 3,377,791
Other food and drink	13,538,705	14,724,557	16,145,652	+2,606,947	108,669,695	108,945,622	113,571,350	+ 4,901,655
Tobacco	776,045	981,774	1,061,395	+ 285,350	4,512,378	3,721,920	4,734,062	+ 221,684
Total, Class I.	16,864,450	19,399,633	21,128,825	+4,264,375	230,644,985	231,299,575	238,229,466	+ 7,584,481
II.—RAW MATERIALS AND ARTICLES MAINLY UNMANUFACTURED :								
Coal, Coke, and Manufactured Fuel	26,862,386	26,061,120	31,504,291	+4,641,905	2,689	42,582	47,100	+ 44,411
Iron ore, Scrap Iron and Steel	500,621	473,326	596,474	+ 95,853	4,599,200	5,525,575	6,766,763	+ 2,167,563
Other Metallic Ores	130,630	114,465	176,091	+ 45,461	6,597,702	7,610,990	9,040,766	+ 2,443,064
Wood and Timber	67,593	77,056	91,710	+ 24,117	23,637,985	23,274,020	27,511,279	+ 3,873,294
Cotton	—	—	—	—	55,024,825	52,370,878	56,125,204	+ 1,100,379
Wool	2,164,823	2,511,711	2,901,726	+ 736,903	23,316,455	26,648,737	30,540,421	+ 7,223,966
Other Textile Materials	179,672	155,477	164,455	− 15,217	13,030,669	14,511,978	17,026,320	+ 3,995,651
Oil Seeds, Nuts, Oils, Fats and Gums	2,759,019	2,592,538	2,826,521	+ 67,502	25,290,505	23,600,927	25,644,240	+ 353,735
Hides and Undressed Skins	1,428,041	1,853,885	2,210,850	+ 782,809	6,576,310	8,084,793	10,699,293	+ 4,122,983
Materials for Paper Making	428,481	535,840	714,293	+ 285,812	3,554,133	3,802,501	3,935,570	+ 381,437
Miscellaneous	1,709,446	1,936,543	2,084,838	+ 375,392	20,582,340	22,633,578	24,172,245	+ 3,589,905
Total, Class II.	36,230,712	36,311,961	43,271,249	+7,040,537	182,212,813	188,106,559	211,509,201	+29,296,388
III.—ARTICLES MAINLY MANUFACTURED :								
Iron and Steel and Manufactures thereof ..	28,066,671	31,826,438	39,880,563	+11,813,892	8,216,772	8,589,405	8,360,135	+ 143,363
Other Metals and Manufactures thereof ..	6,991,421	8,920,533	10,127,102	+ 3,135,681	20,953,877	21,840,696	28,229,260	+ 7,275,383
Cutlery, Hardware, Implements and Instruments	4,891,191	5,115,316	5,882,385	+ 991,194	3,814,587	3,615,107	3,771,646	− 42,941
Electrical Goods and Apparatus (other than Machinery, and Telegraph and Telephone Wire)	1,607,316	2,431,744	2,381,691	+ 774,375	845,873	1,010,304	1,187,565	+ 341,692
Machinery	21,065,191	23,260,326	26,732,693	+ 5,667,502	4,312,440	4,537,871	5,127,187	+ 814,747
Ships (new)	4,455,151	5,431,298	8,685,240	+ 4,230,089	26,196	32,623	28,400	+ 2,204
Manufactures of Wood and Timber (including Furniture)	1,281,678	1,214,039	1,305,569	+ 23,891	2,083,306	1,968,196	2,016,918	− 66,388
Yarns and Textile Fabrics :								
(1) Cotton	83,873,746	92,010,985	99,602,535	+15,728,789	6,648,062	7,920,252	9,326,527	+ 2,678,465
(2) Wool	26,923,563	29,150,610	31,844,608	+ 4,921,045	11,428,539	12,524,037	12,075,874	+ 647,335
(3) Other Materials..	12,414,591	13,204,899	14,979,559	+ 2,564,968	19,385,895	19,244,139	20,081,042	+ 695,147
Apparel	5,745,368	6,021,242	6,818,136	+ 1,072,768	3,512,904	3,952,693	3,785,167	+ 272,263
Chemicals, Drugs, Dyes and Colours	13,647,449	14,536,857	15,526,782	+ 1,879,333	9,211,770	9,624,638	10,102,490	+ 890,720
Leather and Manufactures thereof (including Boots and Shoes, and Gloves)	4,758,999	5,660,494	6,390,980	+ 1,631,981	10,893,182	11,037,983	12,745,138	+ 1,851,956
Earthenware and Glass	3,116,223	3,205,552	3,661,605	+ 545,382	4,337,273	4,312,218	4,219,291	− 117,982
Paper	1,876,797	1,939,767	2,062,611	+ 185,814	4,940,619	5,256,065	5,728,520	+ 787,901
Miscellaneous	22,621,588	25,143,114	29,726,652	+ 7,105,064	25,359,965	27,930,680	29,021,088	+ 3,661,123
Total, Class III. ..	243,336,943	269,073,214	305,608,711	+62,271,768	135,971,260	143,396,907	155,806,248	+19,834,988
IV.—MISCELLANEOUS (including Parcel Post)	4,278,935	5,031,806	5,664,128	+ 1,385,193	2,209,570	2,216,876	2,442,978	+ 233,408
Totals of all Classes £	300,711,040	329,816,614	375,672,913	+74,961,873	551,038,628	565,019,917	607,987,893	+56,949,265

FOREIGN AND COLONIAL EXPORTS FROM THE BRITISH ISLES (Value F.O.B.)				
ARTICLES.	1904.	1905.	1906.	Increase (+) or Decrease (−) in 1906 as compared with 1904.
I.—FOOD, DRINK, AND TOBACCO:	£	£	£	£
Grain and Flour	1,365,894	1,535,143	1,399,352	+ 33,458
Meat, including Animals for food	718,900	813,248	799,787	+ 80,887
Other food and drink :				
(1) Non-dutiable	3,561,448	3,915,340	4,063,026	+ 501,578
(2) Dutiable	4,989,476	5,542,518	5,565,982	+ 576,506
Tobacco	245,402	221,213	221,272	− 24,130
Total, Class I.	10,881,120	12,027,462	12,049,419	+ 1,168,299
II.—RAW MATERIALS AND ARTICLES MAINLY UNMANUFACTURED :				
Coal, Coke, and Manufactured Fuel	72	—	—	− 72
Iron ore, Scrap Iron and Steel	26,533	47,266	27,177	+ 644
Other Metallic Ores	266,553	369,313	495,938	+ 229,385
Wood and Timber	641,090	687,971	909,233	+ 268,143
Cotton	7,242,952	6,988,994	7,100,870	− 142,082
Wool	9,739,345	11,236,257	11,575,035	+ 1,835,690
Other Textile Materials	3,327,977	3,784,248	4,856,008	+ 1,528,031
Oil Seeds, Nuts, Oils, Fats and Gums	4,568,637	4,596,361	4,752,556	+ 183,919
Hides and Undressed Skins	3,961,494	5,107,871	6,523,259	+ 2,561,765
Materials for Paper Making	148,230	153,029	165,909	+ 17,679
Miscellaneous	9,312,478	10,863,795	11,000,969	+ 1,688,491
Total, Class II.	39,235,361	43,835,105	47,406,954	+ 8,171,593
III.—ARTICLES MAINLY MANUFACTURED :				
Iron and Steel and Manufactures thereof ..	385,803	331,192	351,270	− 34,533
Other Metals and Manufactures thereof	4,632,275	5,755,894	7,855,192	+ 3,222,917
Cutlery, Hardware, Implements, and Instruments	668,718	529,138	648,949	− 19,769
Electrical Goods and Apparatus (other than Machinery and Telegraph and Telephone Wire)	57,955	74,191	121,592	+ 63,637
Machinery	881,238	1,134,814	1,522,991	+ 641,753
Ships (new)	4,530	13,359	10,250	+ 5,720
Manufactures of Wood and Timber (including Furniture)	170,258	181,610	179,489	+ 9,231
Yarns and Textile Fabrics :				
(1) Cotton	968,037	1,395,756	2,630,669	+ 1,662,632
(2) Wool	994,120	1,144,772	1,087,304	+ 93,184
(3) Other Materials	3,995,928	3,781,496	3,176,007	− 819,921
Apparel	405,411	369,208	437,508	+ 32,097
Chemicals, Drugs, Dyes and Colours	1,403,287	1,473,578	1,366,915	− 36,372
Leather and Manufactures thereof (including Boots and Shoes, and Gloves)	1,638,445	1,489,853	1,975,256	+ 336,811
Earthenware and Glass	325,684	288,982	184,666	− 141,018
Paper	115,614	90,858	122,133	+ 6,519
Miscellaneous	3,422,235	3,729,288	3,840,876	+ 418,641
Total, Class III. ..	20,069,538	21,783,989	25,511,067	+ 5,441,529
IV.—MISCELLANEOUS AND UNCLASSIFIED :	118,262	133,357	195,946	+ 77,684
Totals, all Classes ..	70,304,281	77,779,913	85,163,386	+ 14,859,105

United Kingdom," a large blue-book in two volumes, which gives very full details of British trade for the past five years. Summaries of these will be found in the "Statesman's Year Book."

The principal articles of home produce exported, and the principal articles imported, in each of the years 1904, 1905, and 1906, are as given on the opposite page.

The Carrying Trade. In addition to the "Special" trade of the country itself, there is a very large transit trade. British ships visit every land of the globe. It is convenient to send articles from the smaller ports of Europe to America or Australia, or the Far East, viâ London or some other British port which has regular communication with other ports. The bulk of it is done through London (nearly 70 per cent. of free goods) and Liverpool (nearly 24 per cent. of free goods). This trade is very valuable. The figures are given in the table of foreign and colonial exports above.

From the table giving a statement of the trade with various countries, which is given on the next page, it will be seen how (*a*) proximity, (*b*) advanced economic development, and (*c*) political attachment count as all-important factors in deciding the amount of our trade. The British trade with different countries has already been noted in previous articles on these countries, and need not be revised here.

Tonnage at the Chief British Ports. This is another indication of the relative importance of our ports. Those ports with a total tonnage of over 1,000,000 tons entered and cleared in 1904 (excluding coastwise trade) are as follow:

	Tons.		Tons.
London ..	17,619,124	Manchester ..	1,912,184
Liverpool ..	14,300,465	Leith	1,886,422
Cardiff	12,791,904	Middlesbro' ..	1,801,153
Tyne Ports ..	8,511,584	Grimsby ..	1,753,048
Hull	4,491,780	Swansea ..	1,678,547
Glasgow ..	4,184,126	Harwich ..	1,556,700
Southampton ..	3,989,069	Grangemouth ..	1,465,153
Dover	3,505,415	Methil	1,323,132
Newport ..	2,881,609	Bristol	1,265,078
Blyth	2,441,660	Kirkcaldy ..	1,073,429
Sunderland ..	2,135,993	Goole	1,069,206

It will prove a useful conclusion to our study of the trade of Britain to consider the trade of the eight most important ports, and some others typical of special regions. The figures are for 1905.

The Trade of London Examined. The exports of United Kingdom produce at London worth over £1,000,000 a year are apparel, arms, chemicals, cotton goods (£7,542,000), machinery and

millwork, medicines, copper, ivory, painters' colours, woollen goods (£5,488,000).

The exports of foreign and colonial produce from London worth over £1,000,000 a year are numerous—raw coffee, raw cotton, hemp, jute, undressed leather, tin, tea, and wool, of which the last is by far the most valuable (£7,290,000). London has more imports than exports, and the imports worth over £1,000,000 per annum are living animals, butter, motor-cars and cycles, cheese, chemicals, raw coffee, wheat, barley, oats, maize, wine, flour, raw cotton, manufactured cotton, dyes, eggs, fish, fruit, glassware, gums, hemp, jute, hops, leather, machinery and millwork, fresh and preserved beef and mutton, copper, iron and steel, lead, tin, petroleum, paper, flax, seeds, linseed, silk goods, skins, sugar, tallow, tea, wine, wood, wool, woollen goods. Wool (nearly £18,000,000) and tea (over £9,000,000) are the most important, as most Eastern and Australian boats come to London.

The Trade of Liverpool. This is based largely on the needs of South Lancashire for a market for its cotton and for an inlet for raw cottons and food. About three-fifths are cotton goods; iron, steel and machinery next. Woollen manufactures, chemicals, hardware, and linen goods (from Ulster) follow. The exports of foreign and colonial produce are very varied. Rubber, raw cotton and wool are the most important.

The imports at Liverpool include much raw cotton; wheat, maize and rice among cereals; meat, fresh and salt; sugar, tobacco, cheese and dairy produce, fish, jute manufactures, leather, unwrought copper, palm and other oils, and timber.

Cardiff and the Tyne Ports. Coal, coke, and patent fuel form most of the exports of Cardiff (over £9,650,000 out of £9,695,000 in 1905). The imports are cereals (mainly wheat), timber, and iron ore.

The Tyne ports are also coal ports, but here ships, with their machinery, iron and steel manufactures, and copper, are additional exports. The imports are butter, wheat, timber, eggs, bacon, lead, silver, iron ore and copper, and refined sugar. These show the connection with Baltic and North Sea lands.

Hull and Glasgow. Hull is a port of a manufacturing district, and attracts trade from a wide area. Wool, woollen yarns and goods are exports not quite so valuable as cotton yarns and goods, while machinery and iron and steel manufactures are the most valuable. Oil and leather are also exports of home origin. Hull is a port which does a considerable transit trade in raw cotton, rubber, machinery, tools, wool, skins, fish, fruits, and seeds. Hull imports cereals (especially wheat and barley), seeds (especially cotton and linseed), sugar, timber, wool, dairy produce, meat, oils. Here, again, the needs of the neighbouring manufacturing district are obviously largely supplied through its port.

Glasgow has a very complex trade in machinery, iron and steel manufactures, and ships, beer and spirits, chemicals, coal, china and earthenware, cotton yarn and goods, jute yarns and goods, linen yarn and goods, wool and woollen goods. The imports include flour, wheat, maize, and other cereals, live animals, meat (especially hams), iron and iron ore, timber, fruit (especially oranges and apples).

Southampton and Dover. The chief exports at Southampton are cotton manufactures, apparel, leather, woollen goods, and books; at Dover, woollen goods and apparel. Southampton has an entrepôt trade in silk manufactures (from France), furs, tea, wool, shells, precious stones, and some rubber; and the transit trade of Dover is one mainly in wool, feathers, and furs.

The imports of the two differ somewhat. Southampton's imports of live animals, cacao and coffee, feathers, fresh beef and bacon, silk manufactures, skins, vegetables, wool and woollen manufactures, show its connection with tropical America, France, and South Africa. Dover's imports—woollens, silk, and cottons, watches, wine, apparel, and embroidery—all tell of its nearness to Continental Europe.

Leith, Bristol, and the Irish Ports. Leith represents, to a certain extent, the trade of Eastern Scotland, though ports like Methil export much more coal. Machinery and iron and steel work are the chief exports; linen and cotton goods, some woollen goods, coal, fish, and oil are others on the list. The imports of Leith are more valuable, and include dairy produce, sugar, wheat, barley, flour, flax, glass, linen yarn, manures, iron and steel, paper, and timber (from Baltic and North Sea ports).

Bristol exports iron and steel manufactures from the Midlands. Like Leith, its imports are worth more than its exports, and are wheat, maize, sugar, dairy produce, fruit, meat, metals.

The Irish ports export little abroad. Belfast sends machinery, ships, and linen yarn, and Dublin a little wool. The imports are considerable, Belfast taking raw cotton, flax, maize, flour and wheat, linen yarn, petroleum, sugar, tobacco, and timber. Dublin imports wheat, flour, and maize, timber, petroleum, and sugar. Cork and Limerick import wheat, maize, and sugar. Maize goes to Derry, Sligo, and Waterford.

BRITISH TRADE WITH VARIOUS COUNTRIES

——	Imports. 1905.	Exports. 1905.
India .. .. £	36,062,291	44,361,153
Australia..	26,968,977	19,476,463
New Zealand	13,391,222	6,994,806
Canada	25,695,898	13,767,079
Newfoundland	508,307	500,888
South and East Africa ..	5,724,662	18,301,382
Straits Settlements ..	6,835,025	3,283,966
Hong Kong	386,440	3,841,735
British West Indies ..	1,956,458	2,263,802
Ceylon	4,477,950	1,435,279
British Guiana	553,663	724,340
Channel Islands	1,666,614	1,321,448
West Africa	2,368,642	3,036,910
Malta	41,158	1,193,337
All other Possessions ..	1,231,413	2,210,332
Total British Possessions	127,868,726	122,712,920
United States of America	115,573,051	47,282,088
France	53,072,900	23,232,663
Germany..	35,799,758	42,742,300
Holland	35,481,059	14,516,887
Russia	32,366,234	14,884,050
Belgium	27,751,288	14,818,923
Argentine Republic ..	25,024,325	13,383,835
Egypt	14,976,188	8,069,668
Denmark	15,416,456	4,476,624
Spain	13,858,631	4,841,774
Sweden	9,827,993	6,016,322
China	2,340,346	13,298,828
Brazil	8,109,208	6,916,617
Italy	3,324,595	9,787,306
Turkey	5,491,443	6,979,147
Japan	1,860,313	9,796,900
Chile	6,068,031	4,782,382
Norway	5,954,870	3,712,532
Portugal	2,929,634	2,826,257
Java	1,890,330	3,012,280
Philippine Isles	1,889,302	2,429,960
Austria	1,488,604	2,603,223
Rumania..	1,689,513	1,305,658
All other countries ..	13,737,119	23,167,373
Total foreign countries..	427,151,191	284,883,607
Grand total .. £	565,019,917	407,596,527

COMMERCIAL GEOGRAPHY *concluded; followed by* ASTRONOMY

continued from page 5916

OIL-FIELDS OF THE WORLD

The World's Petroleum Deposits. Oil Shales. Crude Petroleum. Systems of Drilling Petroleum Wells. Handling Crude Petroleum

By SIR BOVERTON REDWOOD

IN the brief account which is all that can here be given of the numerous oil-fields of the world the comparatively unimportant areas, supplying or partially supplying only local requirements, are necessarily ignored. Of those mentioned, the relative importance changes almost month by month with the discovery of new fields, the variations in activity of operation of those previously in work, and other causes too numerous to specify.

The Wells of the United States. Nearly every State in the Union rejoices in the possession of a greater or less extent of oil-bearing territory, the sole exceptions being some on the Atlantic coast, and some westward of the Great Lakes on the northern frontier. The several States, like the rest of the world, continually vary in the relative importance of their production of petroleum, and a purely geographical course will be the simplest to follow in a rapid sketch of the principal fields.

The Appalachian oil-fields, comprising a great number of more or less independent "oil-pools," or centres of yield separated by barren areas, begin in Allegheny county, New York, and traversing the western side of Pennsylvania and West Virginia, and portions of Kentucky and Tennessee, extend some 50 miles into Alabama, a range of about 700 miles. Throughout this length the lower portion of the Carboniferous system and the subjacent Devonian yield a large proportion of the American output of petroleum, though now beginning to show signs of exhaustion. The great cities of Pittsburg and Allegheny at one time maintained their extensive metallurgical and kindred industries largely by means of the abundant gas present in the sands of the Catskill group at the base of the Carboniferous series, while the richest yield of oil is derived from the Chemung division of the Devonian system.

In Eastern Ohio, the same rock-groups afford petroleum as in Pennsylvania, but in the interior of the State, and also in Kentucky and Tennessee, the yet lower Silurian series supplies large quantities of oil and gas. The oil, however, varies in quality from that of the higher rock-series in containing a considerable amount of sulphur, and requiring special processes for its purification. The difference is probably due to the derivation of the Silurian limestone oil from animal remains, while the paraffin oil of the Devonian and Carboniferous sandstones appears to be of vegetable origin. In the Indiana and Illinois fields, the Carboniferous, Devonian, and Silurian all supply petroleum in varying amounts. Missouri and Arkansas produce but little oil, which is of Carboniferous age. Beyond this, we find a rich oil-field in the lower Carboniferous rocks occupying the south-western parts of Kansas, and extending across Oklahoma and Indian Territory. The belt of these rocks continues across Texas to the Mexican frontier, but apparently in less productive condition, though this may be due not so much to its poverty as to neglect of testing operations, owing to the presence, further eastward in the State, of formidable rival fields in the Cretaceous and Tertiary rocks, where the additional advantage exists of being nearer to the coast of the Gulf of Mexico. Nearly every county in the eastern half of Texas is more or less petroliferous, and especially Hardin and Jefferson. These and others along the Gulf Coast comprise several independent oil-fields, discovered only within the present century. The coastal fields extend from Corpus Christi, Texas, into Louisiana, as far as the Atchafalaya branch of the Mississippi, and may eventually be found to range into Florida. In the West Indian Islands the petroliferous belt may be traced through Cuba, Hayti, Porto Rico, Barbados, and Trinidad, to the coast-fields of Venezuela and Colombia, while in the opposite direction it is more or less continuous from the Texas frontier throughout the Atlantic States of Mexico.

To the west of the great plains of Kansas and Nebraska rise the hills of Colorado, Utah, and Wyoming, with many oil-fields of varying importance. These are mostly in Cretaceous and Tertiary rocks, but the Carboniferous, Triassic, and Jurassic systems afford minor yields in places. California has in recent years advanced rapidly to the premier position among the States in the production of petroleum, especially in the southern half of the State, including Santa Barbara, Ventura, Los Angeles, Fresno, and Kern counties. The productive rocks are of Tertiary age.

On the southern coast of Alaska an oil-field of considerable size and promise has been in course of development for a few years in the Tertiary area eastward of the mouth of Copper River.

British America. The oil-fields of Western Ontario were exploited a few years after the beginning of the commercial development of the petroleum industry in Pennsylvania. The productive rock here is the Corniferous limestone, a member of the Devonian series, not petroliferous to any notable extent in the United States. In the western provinces, Alberta, Athabasca, and Mackenzie, the Cretaceous rocks give promise of a vast output of petroleum when due means of communication and transport are available, but the region cannot be classed among productive oil-fields at present. There are also some petroliferous deposits of Lower Silurian age on the eastern coast of Quebec (Gaspé peninsula), and on the western shores of Newfoundland. Reference has been made above to Trinidad as constituting a link in the chain of oil deposits fringing the Gulf of Mexico. The Pitch Lake, one of the most popular "sights" of the island, drew more attention from travellers than from men of commerce till within the last twenty years, during which the asphalt it yields has been more and more extensively raised, and recently hopes, apparently well-founded, have been entertained of supplies of the more deeply-seated petroleum, of which the asphalt represents the residuum after evaporation of the more volatile elements, and alteration of the remainder. Like all the petroleum of the Caribbean area, it is of Tertiary age.

Russia—The Oil-wells of Baku. The petroleum industry of Baku is probably of as great antiquity as that of Japan, to be described presently. It is mentioned by many ancient and mediæval writers, the discharge of oil-gas in the ancient fire-temple of the Guebers at Surakhani having been the object of perennial pilgrimages from all parts of the East. The Apscheron peninsula, from the natural springs in a few square miles of which the Orient world was long supplied with petroleum, was Persian territory prior to 1723, and is mentioned, under various names, as part of that country by the earlier writers. By degrees other natural outflows were noticed in various parts of the Caucasus, but there was no systematic production from wells till 1806, when a monopoly of the trade was granted to a merchant of the name of Mirzoeff. It was not, however, till the abolition of this monopoly, in 1872, that extensive and rapid development set in. As no other field has yielded such enormous volumes of oil, or afforded such magnificent displays, either of oil-fountains or of wells on fire, the following account is quoted from Marvin of the Droojba fountain, which in 1883 discharged 1,600,000 to 2,000,000 gallons daily, flowing for nearly four months before the engineers succeeded in capping it (closing the lining pipe):

"The fountain was a splendid spectacle—it was the largest ever known in Baku. When the first outburst took place, the oil knocked off the roof and part of the sides of the derrick; but there was a beam left at the top, against which the oil burst with a roar in its upward course, and which served in a measure to check its velocity. The derrick itself was 70 ft. high, and the oil and the sand, after bursting through the roof and sides, flowed fully three times higher, forming a greyish-black fountain, the column clearly defined on the southern side, but merging in a cloud of spray 30 yd. broad on the other. A strong southerly wind enabled us to approach within a few yards of the crater on the former side, and to look down into the sandy basin formed round about the bottom of the derrick, where the oil was bubbling round the stalk of the oil-shoot like a geyser. The diameter of the tube up which the oil was rushing was 10 in. On issuing from this, the fountain formed a clearly defined stem about 18 in. thick, and shot up to the top of the derrick, where, in striking against the beam, which was already worn half through by the friction, it got broadened out a little. Thence continuing its course, more than 200 ft. high, it curled over and fell in a dense cloud to the ground on the north side, forming a sandbank, over which the olive-coloured oil ran in innumerable channels towards the lakes of petroleum that had been formed on the surrounding estates. Now and again the sand flowing up with the oil would obstruct the pipe, or a stone would clog the course; then the column would sink for a few seconds lower than 200 ft., to rise directly afterwards with a burst and a roar to 300."

A River of Oil. "Some idea of the mass of matter thrown up from the well could be formed (this account continues) by a glance at the damage done on the south side in twenty-four hours, a vast shoal of sand having been formed which had buried to the roof some magazines and shops, and had blocked to the height of 6 or 7 ft. all the neighbouring derricks within a distance of 50 yd. Some of the sand and oil had been carried by the wind nearly 100 yd. from the fountain. . . . Standing on the top of the sand-shoal, we could see where the oil, after flowing through a score of channels from the ooze, formed, in the distance, on lower ground, a whole series of oil lakes, some broad enough and deep enough to float a boat in. Beyond this the oil could be seen flowing away in a broad channel towards the sea."

Far larger spouters, less graphically described, were subsequently produced, one in 1893 exceeding 48,000,000 gallons daily. Fairly rich fields extend through the Daghestan, Terek, and Kuban territories on the north flank of the Caucasus, and the province of Tiflis on the south, the Grozni district (Terek) being especially rich. The Taman and Kertch peninsulas, between the Sea of Azoff and the Black Sea, constitute the western end of this prolific belt, which on the further side of the Caspian Sea reaches far into Turkestan. The age of the productive rocks ranges from Oligocene to Miocene in the European portion of the chain, whilst in the Uralsk and Ferghana regions the Cretaceous series is also contributory.

Austria and Rumania. In these countries a practically continuous oil-field extends along the outer flanks of the Carpathian Mountains and the Transylvanian Alps, affording rich yields in Galicia and Rumania, while there are indications, as yet but little developed, on the inner Hungarian side of this long curve. The minor divisions of the Galician area have undergone many changes in relative commercial importance, the Sloboda-Rungurska, Krosno, Gorlice, and Schodnica districts having been at different times the leading centres of production, now quite eclipsed by that of Boryslaw. The latter was long noted for its rich mines of ozokerit, with little suspicion of the wealth of petroleum that lay at greater depth. The ozokerit occurs in marls of Miocene age, which it traverses as plastic veins. The oil is found in the subjacent Oligocene conglomerate, to which wells of great depth have been carried. The Eocene sandstones largely contributed to the earlier production of oil in Galicia, and the Neocomian series has also been found fairly petroliferous in the western districts. In Moldavian Rumania the Eocene is again the productive series, while in the Wallachian fields the Miocene and Pliocene groups afford copious supplies, widely developed.

Germany and Italy. The chief oil-fields of Germany are in Hanover and Elsass. In the latter province oil has been raised for some 400 years past from the wells of Pechelbronn, Ohlungen, and intermediate points, the Lower Oligocene marls being the source. The principal production of Hanover centres around Oelheim and Steinförde, various secondary rocks, chiefly Triassic and Neocomian, being the source of supply. The wide plains of the Luneburger Heide, covered over by more recent deposits, are believed to conceal valuable stores of petroleum in the deep-seated members of the older rock-series. The chalk of Holle, in Holstein, is reported to be charged with petroleum.

Oil was raised and used by the Romans from wells at Agrigentum (now Girgenti), in Sicily, more than 2,000 years ago. That of Miano, Parma, is mentioned A.D 1400. At present the Italian industry is confined to production for local use, and is limited to the Emilian provinces (Piacenza, Parma, Modena, and Bologna), the Abruzzi (Tocco and Manopello), and Campania (San Giovanni Incarico). The sources are of Tertiary age, mostly Eocene, but newer in some cases.

Northern Africa and Western Asia. In Algeria, the oil-fields of the province of Oran occur in Miocene rocks on both sides of the Cheliff valley between Orleansville and Mostaganem. Approxi-

mately, the same age may be assigned to the deposits on the Egyptian shore of the Red Sea, at the mouth of the Gulf of Suez, the Arabic name of the hill, Jebel Zeit, and the Roman name, Mons Petrolius, both connoting the occurrence of mineral oil. In Syria, the oil and asphalt of the Dead Sea were known long before the petty "kings" of the Vale of Siddim met their fate in the "slime-pits" there (Gen. xiv., 10), and supplied the bitumen for embalming the countless mummies, human and other, of Egypt, *mum* being the Coptic for bitumen. In Mesopotamia, the oil-springs of Hit, on the Euphrates, furnished the "slime" cementing the bricks of the Tower of Babel and other vast erections of antiquity, the ruins of which still provide pitch for the gophers (wicker boats payed with asphalt) on the Euphrates and Tigris. In Persia, a great extent of oil-bearing territory is yet awaiting development, from the Turkish frontier above Bagdad, to Bunder Abbas on the Persian Gulf.

Assam and Burma. Profitable operations are in progress at but one point in the long belt of country constituting the foothills on the southern side of the Brahmaputra valley, at many points of which occur evidences of petroleum. The field in work is at Digboi, a few miles north of the present terminus of the Makum branch of the Assam railway system. The productive series is a division of the Miocene, but some petroleum has been found in the Eocene also.

The oil industry of Burma dates from more than a century back, having been in vigorous development in 1795. The chief source then, as now, was the Yenangyaung district, some 275 miles northward of Rangoon. Parts of this, and of the Yenangyat field, 50 miles further north, are crowded with oil-pits sunk by the natives to depths ranging to more than 300 ft., whence the oil is raised by bailing. Within recent years, Western drilling methods have been introduced, and far greater depths attained, resulting in many excellent producers, while fresh areas, within which oil is accessible by the drill, though not by the spade, have been brought to notice by special exploration for their discovery. Traces of petroleum occur in the Eocene rocks, but the Lower Miocene alone yields a supply of commercial value, and this division is exposed at frequent intervals over an area of many hundred square miles. In Cheduba, Ramri, the Baranga, and other islands off the Arakan coast, intermittent attempts have been made, with poor success, to collect the oil there ejected by numerous mud-volcanoes from the uptilted and shattered rocks, also of Tertiary age.

The Eastern Archipelago and Japan. In the islands of Sumatra, Java, and Borneo, petroleum is raised at many points, from beds of presumably the same Upper Tertiary age as those of Assam and Burma. On the north-eastern coast of Sumatra, the Langkat fields range to Edi, in the Atchin province, and a large area in Palembang extends up the Musi to 100 miles westward, and 80 miles southward of the capital. With the further opening up of the east coast, it is probable that other fields will be found in the intervening regions. In Java, a long stretch of country from Samargan to Surabaya and Madura has been found productive, and the traces detected in many other provinces may eventually extend the industry over a large part of the island. In Borneo, again, a belt of petroliferous land appears to occupy the northern coast from Sarawak to beyond Labuan, and rich fields are in work on the eastern coast in Tidung and Kutei provinces. The traces of oil alleged to occur on Celebes, Ceram, and New Guinea, may be mentioned as indicative of the existence of the same productive series at those points, but in problematical extent. The Philippine Islands are reported as petroliferous at many points, and in the Portuguese division of Timor petroleum has been found on its southern coast.

Petroleum occurs in Japan throughout the northern island of Hokkaido or Yezo, and large fields have been worked for many centuries in Nippon, especially on the western coast. The oil-fields of the north-east coast of Sakhalin, not hitherto brought into use, are beyond the Japanese frontier in that island.

South America. As was mentioned above in connection with the West Indian Islands, rich asphalt deposits, with probably stores of unaltered petroleum beneath them, protected from escape or evaporation by the impervious cover of asphalt, occupy large areas in Venezuela and Colombia, but no extensive industry has yet arisen in the latter country. The north-western coast of Peru, from the border of Ecuador down to Point Aguja, a distance of about 180 miles, constitutes an oil-field of great promise. As in the smaller field of Santa Elena, in Ecuador, the productive series is of Lower Miocene age, rising in anticlinal flexures through the general covering of Upper Miocene and Pliocene beds. The inland margin is defined by the spurs of the Andes, consisting of various older rocks. In the Argentine provinces of Salta and Jujuy, and the adjacent regions of Bolivia, the Neocomian rocks are charged with petroleum over wide areas. The empire of Brazil seems to possess no petroleum deposits, but shales from which a fair yield of oil can be extracted by distillation.

Oil Shales. Besides the reservoirs of petroleum and sheets of asphalt distributed, as we have seen, over every part of the world, and in rocks of nearly every geological period, there are deposits of shale and lignitic coal which, while not containing any ready-formed oil, afford by distillation a fair yield of various hydrocarbons akin to or identical with the natural petroleums. A wide area of such shales occurs in the Lothians of Scotland, westward of Edinburgh, in the lower part of the Carboniferous series, and the coast of Dorsetshire possesses a belt of oil shale of Upper Jurassic age. In France, the upper part of the Carboniferous series has valuable deposits of shale at Autun and Buxière, and in Southern Spain the Lower Jurassic shales are practically unworked. In Prussian Saxony, between Halle, Leipzic, and Zeitz-on-Elster, is a large area of Oligocene beds with oil-lignites and shales, extensively worked for paraffin and lubricating oils. In Servia, the Lower Miocene oil shales occupy important areas near Alexinatz, and in the Kolubara valley. In South Africa, the Portuguese territory north of Delagoa Bay is reported to possess a coast belt of Cretaceous shales of considerable width and good yield. In New South Wales, the Carboniferous series affords valuable oil shales, mined over a wide area. In New Zealand, oil shales of Tertiary age occur in Auckland and Otago. Lastly, along the coast of Brazil from the mouth of the Amazon, for more than 1,200 miles to the south, deposits of oil shale of Eocene age occur in recesses between the spurs of the ancient crystalline rocks.

Physical Properties of Crude Petroleum. The unusual character of petroleum was the subject of much speculative comment by early writers on philosophical subjects. Thus Francis Bacon in 1627 described "the original concretion of bitumen" as a mixture of fiery and watery substance, and stated that "flame attracts the bitumen of Babylon afar off." Numerous references to

the inflammable nature of petroleum were also made by the ancient historians. In his Life of Alexander, Plutarch describes how, in the district of Ecbatana (Kerkuk) Alexander was particularly struck with "a gulf of fire, which streamed continuously, as from an inexhaustible source. He admired also a flood of naphtha not far from the gulf, which flowed in such abundance that it formed a lake. The naphtha in many respects resembles the bitumen, but it is much more inflammable. Before any fire reaches it, it catches light from a flame at some distance, and often kindles all the intermediate air. The barbarians, in order to show the king its force and the subtilty of its nature, scattered some drops of it in the street which led to his lodgings, and standing at one end, they applied their torches to some of the first drops, for it was night. The flame communicated itself quicker than thought, and the street was instantaneously all on fire. . . ."

Hatchett, writing in 1798, divided bituminous substances into naphtha, petroleum, mineral tar, mineral pitch, asphaltum, jet, pit coal, bituminous wood, turf and peat, and stated that when *naphtha*, the light, thin, often colourless oil, lost its lighter parts by exposure to the air, it yielded *petroleum*, which on further exposure gave *mountain* or *mineral tar*. Continued exposure, he added, produced *mountain or mineral pitch*, which in cold weather became brittle, but was soft and somewhat tenacious when warm, and by further induration *asphaltum* was produced.

Crude petroleum varies greatly in appearance, some descriptions being of pale colour and highly mobile, while others are viscid and almost black. The prevailing *colour* of the more fluid kinds of crude petroleum is chestnut brown, when viewed so that the light passes through the oil, but when the light is reflected from the surface of the oil the colour appears to be olive green. An important indication of the character of a crude petroleum is afforded by its *specific gravity*, which is the ratio of the weight of a given bulk to that of an equal volume of water at 60° F.

Specific Gravity. The specific gravity of crude petroleum ranges from a little under 0·775 to a little over 1·0; therefore, the lightest crude petroleum is about three-fourths the weight of water, and the heaviest about the same weight as water, but as it is exceptional to find crude petroleum approximating in specific gravity to the higher limit, the general experience is that it freely floats on water. When the area of a sheet of water on to which petroleum is flowing is sufficiently large in relation to the quantity of oil, the petroleum immediately spreads out into an exceedingly thin film which, on account of its tenuity, is iridescent, or in other words, exhibits the colours of the rainbow, just as a soap-bubble does. This characteristic film has often led to the discovery of a valuable source of petroleum. Most descriptions of crude petroleum employed as a source of the usual commercial products have specific gravities between 0·8 and 0·9, but even within these narrower limits the specific gravity is a valuable guide to the nature of the oil. As a rule, the lighter the oil the larger the proportion of kerosene or burning oil obtainable from it, and if the specific gravity exceeds 0·9, the petroleum will usually be found best suited for use as a fuel, or, in some instances, for the manufacture of lubricating oils. The *flash point* of the oil, or the temperature at which it gives off inflammable vapour when tested in a prescribed manner (to be hereafter described), also affords an indication of the character of the oil. Most crude oils freely evolve inflammable vapour at ordinary temperatures, but if the oil requires to be heated considerably in order to cause the rapid evolution of vapour, it may be safely assumed that it is of little value as a source of kerosene, still less of the more volatile petroleum spirit used in motor vehicles. The *odour* of the oil is also a feature to be noted, for petroleum containing the objectionable impurity sulphur usually has an offensive odour, the normal odour of petroleum of high quality being not unpleasant. The temperature at which crude petroleum, which is quite fluid when warm, becomes solid on cooling, affords an indication of the proportion of solid constituents present, which can be separated in the process of refining as paraffin wax, for candle-making. Thus, the crude petroleum of Burma, which yields a large percentage of this valuable commercial product, is solid at common temperatures, but becomes quite fluid on being warmed.

Chemical Properties of Crude Petroleum. To Hatchett, who has been already referred to, belongs the credit of having been among the first to form a clear conception of the chemical composition of petroleum, for he stated, quite correctly, as early as 1798 that "the elementary principles of bitumen are carbon, hydrogen, sometimes azote (nitrogen), and probably some oxgyen." The *carbon* appears to range between 79·5 and 88·7 per cent., and the *hydrogen* between 9·6 and 14·8 per cent. The proportion of *nitrogen* rarely approaches 1 per cent., and is usually very much lower than this. *Oxygen* also occurs only in small quantities, usually in the form of an acid. Some oils contain as much as 2 per cent. of sulphur, an impurity which frequently necessitates the adoption of a special refining process for its elimination. The carbon and hydrogen, of which all descriptions of crude petroleum are principally composed, occur in the form of liquid or solid chemical compounds termed *hydrocarbons*. Of these compounds, a large number have been isolated for examination, and it has been found that they constitute well-defined groups. Thus, the crude petroleum of the United States consists chiefly of a regular series of the compounds known as *paraffins*, each containing twice as many atoms of hydrogen as of carbon, and two atoms of hydrogen in addition, while that of Russia consists principally of the compounds termed *naphthenes*, in which there are twice as many atoms of hydrogen as of carbon. Thus, among the hydrocarbons separated from American petroleum we have at one end of the series C_5H_{12}, C_6H_{14}, C_7H_{16}, etc., and at the other end $C_{25}H_{52}$, $C_{27}H_{56}$, $C_{30}H_{62}$; while the hydrocarbons separated from Russian petroleum include C_6H_{12}, C_7H_{14}, C_8H_{16}, etc., up to $C_{15}H_{30}$. These hydrocarbons exhibit regular progression in the *boiling point*, those with least carbon being the most readily volatilised, and those with most carbon having the highest boiling points. This character enables the petroleum refiner to classify the hydrocarbons present by the process known as fractional distillation, so as to obtain the desired commercial products.

The Production of Crude Petroleum. The operation of obtaining petroleum by the drilling of wells, which is technically termed "production," has been systematically conducted only during the past half century; but the collection of the oil by the primitive process of skimming it from the surface of stagnant water, or bailing it from shallow excavations, was practised for ages previously, the oil being used as a lubricant for cart axles, as a preservative of woodwork, especially of boats, and to a smaller extent as a medicinal

agent. Before the drilling of wells was begun, there was an intermediate stage, during which petroleum wells were dug in the same fashion as a water well, and were commonly lined with wood. In some countries, and notably in Burma and Rumania, the sinking of such wells was carried out with great ability and success, remarkable depths being reached, notwithstanding the difficulty and danger of the work, arising from the presence of suffocating vapour.

The Earliest Uses of Petroleum. The earliest detailed description of the collection of petroleum is that given by Herodotus, who describes operations which were carried on at the pits of Kir ab ur Susiana (Kirab, 57 miles north-west of Shuster, in Persia).

Marco Polo, writing at the end of the thirteenth century, says of the petroleum of Baku, on the Caspian Sea: "On the confines towards Georgine there is a fountain from which oil springs in great abundance, inasmuch as a hundred shiploads might be taken from it at one time. This oil is not good to use with food, but is good to burn, and is also used to anoint camels that have the mange. People come from vast distances to fetch it, for in all countries round there is no other oil."

Petroleum in England. There are many historical references to the occurrence of petroleum in England. An interesting case of the sudden influx of petroleum into a water well at Ashwick Court, near Shepton Mallet, in Somersetshire, in the year 1892, was investigated at the time by the late Mr. Topley and the author. The well in question, which was the sole source of the water supply of the house, yielded for some hours after the occurrence of an earthquake shock a considerable quantity—stated to amount to several barrels—of petroleum. On the other hand, several reported discoveries of petroleum have undoubtedly been explicable on the assumption that the oil had leaked from neighbouring petroleum stores. In the United Kingdom in recent years small quantities of petroleum have been obtained in North Staffordshire and Yorkshire, and during 1905 there was a production of 46 tons in Dumbartonshire.

Modern Drilling Plant. The modern appliances most largely used consist of a percussion drill, driven by steam power, by means of which the rock is broken up and mixed with water to the consistency of mud, the detritus being removed from the borehole from time to time by the use of a long iron cylinder having a valve at the lower end. To a comparatively small extent a system of percussion drilling is also employed in which a stream of water under high pressure is driven through hollow drilling rods and issues from orifices in the cutting instrument or bit, the detritus being thus continuously washed out of the borehole. Within the last few years a rotary drill with a circular cutting edge has been largely employed in the oil-fields of Texas and Louisiana, and is now being tentatively introduced elsewhere.

Cable System. There are several forms of percussion drill, chiefly differing in details, but there are only two to which it is necessary to direct special attention, as it is with these that the greater part of the work of drilling for petroleum has been, and is being, done. These are the American or cable system, in which the drilling tools are suspended by a manilla cable, and the Canadian, or rod system, with the modification used in Russia, in which the tools are attached to a string of jointed rods of wood or iron. The general appliances are substantially similar in these two systems, and it will therefore suffice to give a detailed description of the American or cable tools and machinery.

Oil-well Rig. The illustration shows a simple form of the standard rig employed in American oil-fields. The derrick is a strong timber structure, usually at least 70 ft. in height, and 20 ft. square at the base, resting on wooden sills and fixed by means of keys, so that it may be readily taken down and set up on a new site. To the band-wheel, which is fixed on the foundations a short distance from the derrick, motion is communicated by means of a belt from a horizontal steam engine of 12 to 15 horse-power, fitted with reversing gear. While drilling is in progress, this band-wheel imparts motion to the walking beam, one end of which is immediately above it, through the medium of the crank and the wooden connecting-rod, or *pitman*, the length of stroke being adjustable as shown in the illustration. At the opposite side of the derrick is a strong windlass, termed the *bull-wheel*, which is driven from the band-wheel, when required to be used, by means of an endless rope. The bull-wheel is provided with a powerful brake. A smaller windlass, called the *sand-pump reel*, is placed so that it can be driven off the band-wheel by a friction-pulley, actuated by a lever pivoted to the derrick floor. The throttle-valve of the engine is opened or closed by means of an endless cord passing into the derrick, the motive power being thus under the control of the driller. The drilling tools are attached to an untarred manilla cable, 2 in. in diameter, which is coiled round the bull-wheel shaft and passes thence over a pulley at the top of the derrick, but when drilling is in progress they are suspended from the end of the walking-beam over the mouth of the well, and thus have the necessary vertical motion imparted to them. The string of drilling tools consists of two parts separated by the jars, the lower one giving the downward blow, and the upper imparting an upward stroke, which serves to loosen the bit if it has become jammed in the rock. The lower portion consists of the bit, the auger-stem, and the lower half of the jars, while the upper portion consists of the upper half of the jars, the sinker-bar, and the rope-socket with temper-screw. The bit is a steel-faced chisel-shaped implement, about 4 in. in thickness and of a width corresponding with the desired diameter of the borehole. The auger-stem is a solid rod, about 4 in. in thickness, and about 32 ft. in length. The jars may be described as resembling two long flattened links of a chain. The sinker-bar is another solid rod about 12 ft. in length. The rope-socket is an arrangement for grasping the cable, and the temper-screw is a device for gradually lowering the string of tools as the drilling progresses. The various component parts of the string of tools are connected by male and female screws, the collars being squared for the application of wrenches.

Drilling the Well. In beginning a well, an ordinary shaft about 8 ft. or 10 ft. square is dug to a depth of 10 ft. or 15 ft., and a strong iron pipe furnished with a sharp steel shoe is driven down to a depth of 200 ft. or 300 ft., or until hard rock is encountered. The drilling tools suspended to the walking beam are then set to work, and the rock is broken up by the successive blows of the bit. From time to time the walking beam is disconnected, the bull-wheel set in motion, the tools drawn up into the derrick, and the detritus removed from the borehole by means of the sand-pump. This is a long iron cylinder, with a valve at the lower end, opening inwards. It is suspended from a cord passing over a small pulley at the top of the derrick to the

sand-pump reel. On being lowered to the bottom of the well, the valve opens, and the cylinder fills with the detritus, which has been brought to the consistency of mud by means of water poured into the well as the drilling proceeds. On being raised by bringing the friction-pulley into contact with the band-wheel, the valve closes, and the contents of the cylinder are removed. While the tools are in the derrick opportunity is taken to sharpen the bit if it has become blunted.

Casing the Well. In some formations the drilling cannot be carried far without lining the well with iron casing to support the walls, and when a water-bearing stratum is perforated it is the practice to exclude the water by making a seating for this casing on a lower-lying impervious stratum, and continuing the drilling with a smaller bit and with the use of casing of less diameter, each string of casing extending to the surface. Apart from the necessity which may thus arise for reducing the diameter, it is usually found that when a considerable depth has been reached the casing becomes so firmly held by the walls of the well that it cannot be forced down any further, and a smaller string has then to be inserted, with the result that wells of a depth of, say, 2,000 ft., or from 2,000 ft. to 3,000 ft. may contain, when completed, many strings of casing.

Canadian System. The original Canadian, or *rod*, system differs from the system already described in the following particulars:

1. The substitution of wooden boring rods for the cable.
2. The use of an auger in place of the spudding bit in beginning the well.
3. The adoption of a somewhat different arrangement for transmitting motion.
4. The employment of a lighter set of drilling tools.

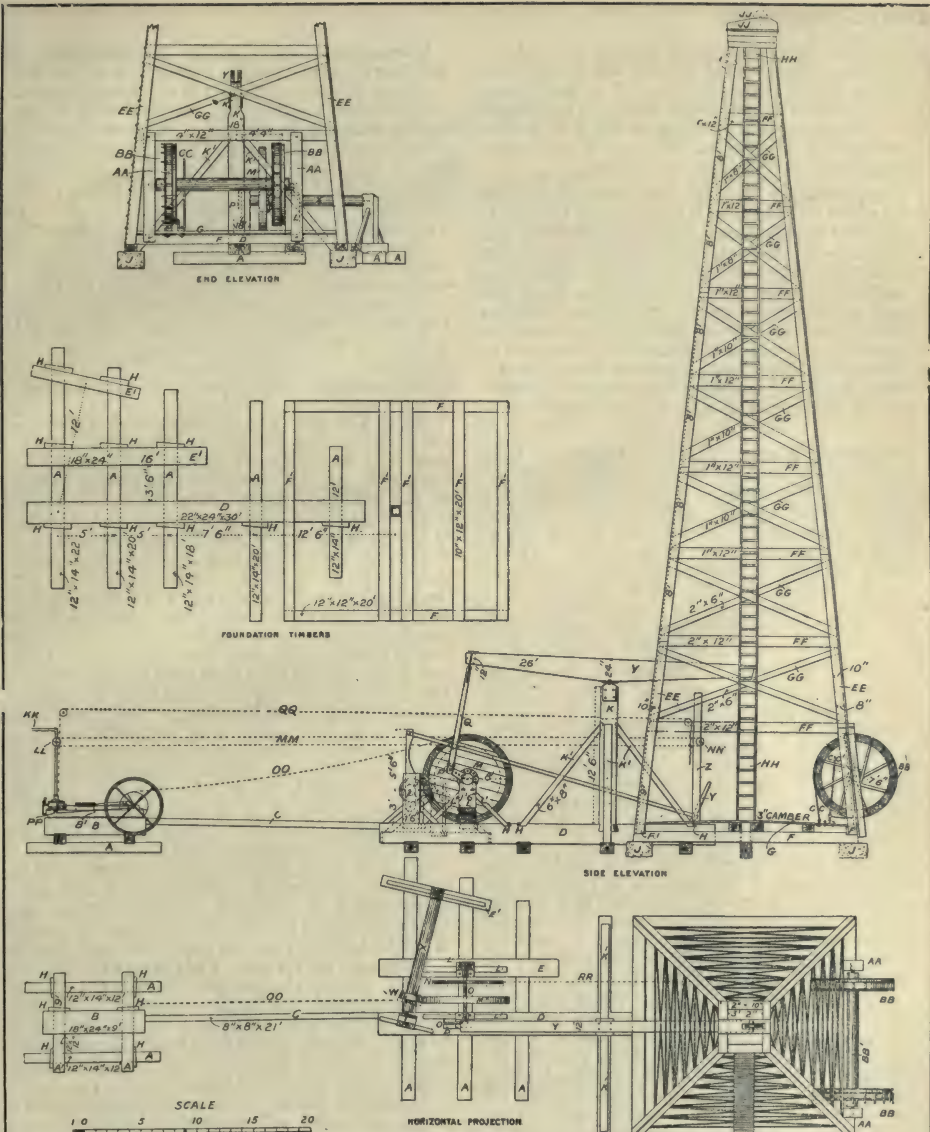
Russian System. In Russia (Baku oil-fields) the wells are of large diameter (sometimes as much as 36 in. at the top) in order to reduce the risk of choking, through masses of rock being driven into the bottom of the borehole by gas pressure, and to admit of the use of bailers of large size in raising the oil, the presence of sand preventing the employment of ordinary pumps. The drilling of wells of this large diameter is a comparatively slow and costly operation, necessitating the adoption of heavy tools and strong appliances generally. The system of drilling may be described as a modification of the Canadian system in which iron rods are substituted for the wooden rods. Owing to their large diameter the Russian wells are chiefly lined with riveted iron-plate casing instead of with the screwed artesian casing used in America.

Galician System. When the Canadian system was introduced into Galicia it was found that considerable increase in the size and weight of the tools was rendered necessary by the greater hardness of some of the strata and the depth of the wells, but in principle the system remained substantially the same until recently. Now, however, it has become customary to employ a combination of the rod or pole system with the cable system, owing chiefly to further increase in the depth of the wells, which renders the time lost in disconnecting and re-connecting the screw-jointed poles a serious drawback, but in making this change a wire rope has been adopted in place of the manilla cable used in America. In addition to the ordinary drilling tools, an expanding reamer is largely used in Galicia. This device is provided with two pivoted wings or dogs, forced outwards by powerful springs, and by means of it the size of the borehole can be increased at the bottom so as to admit of the casing descending freely.

Fishing Tools. In addition to the drilling tools employed in the various percussion drilling systems, a large number of "fishing" tools, many of which are of ingenious construction, are needed to deal with various mishaps which occur. A fracture of the drilling tools or cable or rods is not infrequent, or some portion of the string of tools may become detached, and in the absence of suitable appliances the well might have to be abandoned. By means of the fishing tools the broken end of a cable or rod can be grasped, or a hole drilled in a fractured tool lying at the bottom of the borehole and tapped to receive a screw so as to admit of its being raised.

Rotary System. The rotary system of drilling, already alluded to as being in use on the coastal plain of Texas and elsewhere, is based upon that of Fauvelle, which was invented in 1842. It is admittedly one of the most rapid and economical systems which can be adopted in formations to which it is suited, but where very hard rock is encountered it is almost useless. It consists essentially in the employment of hollow drilling rods or casing terminating in a drilling bit, or annular cutter, through which a continuous stream of water is pumped under a pressure ranging from 40 lb. to 100 lb. per square inch. The derrick is similar to that which has been described, but it is provided with a revolving table and gearing for rotating it by steam power, by means of which the rotation of the casing and bit is effected. The drilling tools are supported by a cable which passes from a swivel attached to them through a block and fall, and over a pulley at the top of the derrick to the hoisting drum. A flexible hose-connection is made from the swivel to the water pumps, of which there are two, in order to insure a continuous supply of water. The bits commonly employed are the fish-tail, the core-barrel, and the adamantine or shot-drill. The fish-tail bit is used for drilling in soft strata, such as sand and clay; the core-barrel bit in harder material, such as very compact clay, indurated sand, etc. In hard rock these two bits are ineffective, the progress made with them being very slow—in some cases only a few inches per day. Under these conditions the adamantine or shot-drill is used, the abrasion of the rock being effected by steel shot, which are caused to revolve by the action of the bit. The detritus is carried continuously to the surface by the current of water passing downwards through the hollow rods or casing and ascending in the annular space outside, and there is thus no need for the periodical clearing-out of the borehole by means of a sand-pump, as in the ordinary percussion drilling system. If a porous stratum is met with the water is liable to percolate into the rock, and to prevent this the water which is being pumped in is mixed with fine clay or mud, the porous bed being thus cemented up. In the Texas fields wells have thus been drilled in a couple of months, or even less, to a depth of 1,000 ft. to 1,200 ft. As the wells in these fields have usually flowed on completion, it has been usual to fit a gate-valve to the top of the casing before drilling into the oil-bearing formation, so that the flow of oil may be controlled.

Depth and Cost of Wells. In Pennsylvania the wells range in depth from 300 ft. to 3,700 ft. Those of average depth cost about $3,000, but the deeper ones may cost as much as $7,000. In Indiana the depth of the wells ranges



FOUNDATION

a Mud-sills
a' Cross sills for engine blocks
b Engine-block
b' Engine
c Engine-block brace
d Main sill
e Sub-sill for jack post of band-wheel
e' Sub-sill for jack post of sand pump reel
f Derrick sills
f' Derrick-floor sills
g Derrick floor
h Keys or wedges
i Conductor
j Corner stones or blocks

SUPERSTRUCTURE

k Samson-post
k' ,, ,, braces
k'' ,, ,, irons
l Band-wheel jack posts
l' Braces of ditto
m Band-wheel
n ,, ,, bull-rope pulley
o Band-wheel shaft
o' Band-wheel arm
p ,, ,, wrist-pin
q Pitman
r Knuckle-post for sand-pump reel
s Jack post for ditto
t Upright lever
u Connecting bar
v Hand-lever in derrick
w Friction pulley of sand-pump reel
x Shaft of sand-pump reel
y Walking beam
z Headache post
aa Bull-wheel posts
bb Bull-wheels
bb' Bull-wheel shaft
cc Bull-wheel brake-band
cc' Bull-wheel brake-band lever
ee Derrick stiles
ff ,, girths
gg ,, braces
hh ,, ladder
ii ,, sand-pump pulley
jj ,, crown pulley
jj' ,, ,, ,, block

GEARING

k Steam-pipe connecting with boiler
ll Throttle-valve
mm "Telegraph" cord which operates throttle-valve
nn Pulley in derrick for telegraph cord
oo Driving-belt
pp Reversing-link of engine
qq Cord operating ditto from derrick
rr Place of the bull-wheel rope

PETROLEUM RIG USED IN AMERICAN OIL-FIELDS

from 900 ft. to 1,650 ft., and the cost from $1,200 to $1,500. The average cost of the Texas wells is about $2,000. The deepest well in the United States is said to be one drilled for water in Connecticut, which reached a depth of 6,004 ft. with a diameter of 6 in. The second deepest was one in Pennsylvania, with a depth of 5,575 ft.

Torpedoing Wells. In some of the oil-fields of the United States it is customary to explode a charge of nitroglycerine at the bottom of the well in order to fracture the adjacent rock and thus facilitate the inflow of oil, as much as 100 or even sometimes 200 quarts of the explosive being employed in the deeper wells. The nitroglycerine is carefully lowered into the well in a series of tin canisters from 3½ in. to 5 in. in diameter and 10 ft. in length, the charge being exploded by means of a "go-devil squib" holding about a quart of nitroglycerine and furnished with a percussion or time fuse.

Flowing Wells. In some localities a large proportion of the wells flow on completion, and not infrequently the stream of oil gushes from the borehole with almost uncontrollable violence, creating a spouter or fountain which may rise in the air to a height of 200 ft. or 300 ft. This is notably the case in the Baku oil-fields, where the pressure exerted by the oil is said to have occasionally amounted to as much as 300 lb. per square inch. If the well spouts to a great height, the oil-spray is liable to be carried by the wind to a considerable distance and ignition may occur at some boiler-fire, with the result of communicating flame to the well. A block of cast iron, about 4 ft. square and 6 in. to 8 in. in thickness is, therefore, placed in the derrick at a height of about 25 ft. above the mouth of the well, and the oil playing against this is confined to the immediate neighbourhood of the well. As soon as possible the oil is led into an excavation in the ground near the derrick, but although such a reservoir holds from 4,000 tons to 6,000 tons, it is quickly filled with oil and sand if the fountain is a strong one, and the derrick may even be buried in a sandhill in a short time. In such cases great loss of oil is unavoidable. The life of a fountain is very uncertain. The violent outburst often lasts only for a few days or weeks, but the fountain may continue to play for more than a year. When the Baku wells do not flow the oil is raised by means of bailers, which are long cylinders, similar to the sand-pump already described, with a valve at the bottom, for ordinary pumps cannot be used, owing to the large quantity of sand contained in the oil. Compressed air is also to some extent used to force the oil to the surface. From the earthen reservoirs the oil is pumped into cylindrical steel storage tanks after the sand has settled out of it, and is thence conveyed by pipe-lines to the refineries.

Yield of Wells in the United States. Although in some of the oil-fields of the United States flowing wells yielding very largely are obtained, the average initial daily production of the whole of the productive oil-wells drilled in 1903 in the Appalachian oil-field (embracing the producing region in New York, Pennsylvania, West Virginia, Kentucky, Tennessee, and the south-eastern portion of Ohio) was 11·8 barrels per well. The term initial daily production signifies the quantity that any new well will produce during the first day after it has been completed.

Transport of Crude Petroleum. In the days of King Theebaw the produce of the wells in Upper Burma was carried in earthenware vessels, and in that country the construction of a pipe-line to Rangoon is only now (1907) on the eve of being begun. For many years past, however, the oil has been brought down the river in bulk-barges, termed flats, by the Irrawadi Flotilla Company. In Russia, until 1875, the crude oil was carried in barrels on Persian carts, known as "arbas," with huge wheels, 8½ ft. to 9 ft. in diameter, one barrel being placed in the body of the vehicle, and a second slung beneath the axle. In the United States the oil was at first transported in oak barrels, but after a short time bulk-barges, and an early form of tank railway-car with two wooden tub-like tanks, were employed. In 1871 railway-cars with the present form of horizontal cylindrical iron or steel tanks were introduced.

Pipe Lines. The first successful pipe-line in the United States was laid in 1865, but it was not until 1875 that the construction of the great trunk lines was rendered necessary by the transference of the refining industry from the neighbourhood of the wells to the Atlantic seaboard, and the shores of the great lakes. In 1892 the aggregate length of the trunk lines (chiefly 6 in. and 8 in. in diameter) was nearly 3,000 miles, several of the individual lines being from 200 to 400 miles in length. In addition there was a network of feeder-lines of smaller size, bringing the total length of piping up to about 25,000 miles. Since that date the number of lines and their capacity have been very largely increased. The trunk pipe-lines are made up in 18-ft. lengths of specially made lap-welded iron or steel pipe, tested to 2,000 lb. per square inch, connected by long-sleeve screwed couplings, and are usually laid two or three feet below the surface of the ground, with bends at intervals to provide for contraction and expansion. The oil is forced through the lines by specially constructed pumps, which keep the column of oil in constant motion at a uniform rate of about three miles an hour, and in order to keep the lines clear of sediment a rotary scraper with radial arms, known as a *go-devil*, is from time to time forced through with the oil. The lines are worked in sections, with a pumping station for each portion.

Storage of Crude Petroleum. At convenient centres storage installations are erected. The tanks employed for this purpose in the United States are vertical cylindrical iron or steel tanks 90 ft. in diameter, and 30 ft. in height, holding about 35,000 barrels. The tanks have slightly conical roofs covered with sheet iron.

Natural Gas. In the account already given of the geological and geographical distribution of petroleum a brief allusion was made to the gas so largely obtained in some portions of the Appalachian oil-fields. The gas wells are similar to the oil wells; indeed, a well drilled for oil occasionally produces gas, and gas wells after a time yield oil. The pressure under which the gas is met with may be as much as 800 to 900 lb. per square inch, and some wells have yielded about 30,000,000 cubic ft. daily. The gas is conveyed from the wells to distributing stations in pipe-lines similar to those used for oil.

Ozokerit. This is one of the solid forms of petroleum, and is mined in Galicia by means of shafts and galleries, similarly to coal, but exceptionally heavy timbering and efficient ventilation are needed.

Continued

HEATING, VENTILATING, & LIGHTING

Varieties of Heating Installations. Natural and Artificial Ventilation. Comparative Values of Various Lighting Systems

Continued from page 5840

By Professor R. ELSEY SMITH

HEATING AND VENTILATING

SOME means of artificially raising the temperature of living rooms during at least part of the year is essential in this and in many countries, and apart from this it is necessary to provide for the means of cooking food and heating water for domestic use. These requirements may be met in a variety of ways, depending to a considerable extent upon custom, but varying with the circumstances of the building to be dealt with. In ordinary dwellings in this country, the open fire is the usual method of warming rooms, whereas in some continental countries closed stoves are employed, and in America some general system of heating with hot water is very usual, even in private houses. General systems of warming are employed in this country for many classes of public buildings and, more rarely, in private ones. The open fireplace, though it has certain disadvantages, is the usual and favourite method of domestic heating; recent improvements have greatly increased the efficiency of many kinds of grates and fires, and this system of warming has this in its favour—that it does much to promote ventilation by providing in every room a suitable outlet and setting up powerful currents in the atmosphere.

Distribution of Heat. A heated body parts with its warmth either by radiation or by conduction or by a combination of the two. In the open fire the heat is distributed by radiation, passing through air, which is a bad conductor, and warming any body that it encounters. In the closed stove and in most forms of heating apparatus the heat is distributed by conduction; the air immediately in contact with the apparatus has its temperature raised and then moves away, and is replaced by air at a lower temperature which is in turn heated and displaced. A free movement of the air is essential to satisfactory heating by conduction, because air, being in itself a bad conductor, if confined so that it cannot move freely, cannot readily conduct heat from one body to another. In the case of an open fire the air of the room is also heated to some extent by conduction; but this is not directly by the fire itself, but is due to the air coming into contact with bodies warmed by the fire.

Cause of Draughts. When a fire burns in an open grate it heats the air which is directly over the fire, or which is drawn through the fire itself, rarefies it, and the air tends to rise in the smoke flue provided above. The fireplace opening sets up a strong current of air which carries off with it the products of combustion and the unconsumed particles.

This air is drawn directly from the room and must be replaced by an equal amount of air from other sources; unless some special means of access is provided—and this is not usual in the smaller class of house—the air will find its way between the sashes and frames of the windows and between the doors and their frames, especially the latter; the general tendency in such cases is for the air to find its way direct from the door to the fireplace near the floor level, producing a sense of draught or at least of coldness.

The necessary amount of air must come from somewhere, and the amount is considerable; some grates require five or six cubic feet per second, and the smaller the openings through which the air is drawn the greater will be the velocity with which it enters and the keener the draught; if the joinery fits very well it may even happen that the supply will be inadequate and the fire will not burn well.

Down Draught. When two rooms are in communication—as for example a front and back drawing-room in many London houses—a fire burning in one grate frequently draws the air it requires down the flue of the other fireplace; if there is no fire burning in the other grate the air is readily drawn down, and with it sometimes smoke from a neighbouring chimney, or noxious vapours from a neighbouring drain ventilating pipe if there be one; hence the warning already given to avoid taking such pipes up in the neighbourhood of chimneys.

If there should be a fire burning in the other grate it may be induced to smoke by the action of the stronger fire, or at least be prevented from burning efficiently. Even where rooms are not in direct communication, air is frequently drawn down one or more of the flues of those fireplaces in which fires are not burning. It will, therefore, be easily understood that the supply of an adequate inlet for fresh air in the immediate neighbourhood of a fireplace not only tends to promote the efficiency of the fire but also reduces the tendency to create a draught across the floor surface, which is so often met with.

Varieties of Grates. All forms of open grates are liable to the objection that the fuel burnt in them is wastefully employed, much of the heat passing away with the products of combustion; but some forms of grates are much more wasteful than others. The old-fashioned forms known as the *hob-grate* [**1**] and the *register stove* [**2**], of which there were many varieties, were extremely extravagant. In both, the receptacle for the fire was raised high above the hearth and had vertical or horizontal bars in front and horizontal fire bars below; the air had free access not only to the front and upper surface of the fire, but to its under surface, and was drawn up through the fire and resulted in rapid combustion of the fuel. Such stoves were usually mainly of iron with the addition in many cases of thin firebrick backs and cheeks. Modern grates are mostly constructed so that the fire is either close to, or actually on, the hearth [**3** and **4**], and when slightly raised a movable front termed an *economiser* [**5**] is provided so as to close the opening entirely after the fire has been lighted and is burning briskly. Though varying somewhat in detail most modern fires have the back and sides of thick fireclay, generally about 2 in. thick, and the sides are usually placed not square, but on a splayed line, while the back is sloped forward over

the fire [5]. The object sought to be secured by this form is to make the utmost use of the fuel, which directly heats the back and sides, and these in turn radiate the heat into the room, and being thick retain a considerable amount of heat after the fire has died down; all such modern grates are more efficient and economical than the old ones. Some of them have no ironwork at all except the bottom bars. Such grates were first introduced by Dr. Teale. The fire in them is sunk below the level of the hearth, which is raised above the floor level, and access for air is arranged under it by means of an opening which can be closed after the fire is once lighted. The *interior*, as it is termed, in which the fire is lighted, is of firebrick in one or two pieces and the front may be formed of glazed bricks or tiles or faience.

Other fireplaces are formed with but little more ironwork; a metal frame is attached to the front of the interior, which includes the front bars to the fire, and this form is well adapted for use with tiled jambs and top; these are finished behind the metal frame, which may be ornamental in form and often includes an ornamental canopy, fixed or movable. Iron, brass, copper, and armour steel are used in this work, either alone or in combination, and around the opening there is added an ornamental mantel and, perhaps, an overmantel which is a purely decorative feature and is regulated by taste and means.

Ventilating Grates. The necessity of an ample air supply has already been referred to, and some grates are designed not only to provide for this, but to ensure that this air shall be warmed before it enters the room. This is effected by forming behind the firebox, or interior, a chamber surrounding the back of the fire, into which the air is admitted cold from outside and from which it may be discharged after it has passed round the grate and has become warmed, into the room. Such a grate may be formed with an iron frame having projecting gills at the back, which increase the radiating surface and assist in warming the air. This class of grate is not very extensively used, but it avoids the draughts that are inevitable with the ordinary grate, unless some special air flue for supplying it with air is provided.

Stoves are not formed open, like a fireplace, but have a casing usually of iron, lined with firebrick. The fire is lighted within, and a pipe conveys the products of combustion to a flue. Such a stove may stand away from any wall, instead of being placed in a recess, so that the heat may be distributed in all directions, and the external surface is usually provided with ribs or gills, to increase the area of heating surface. The fire is entirely enclosed, and is not seen, and the air is heated by conduction. Such stoves are not much employed in this country for domestic heating, as they are on many parts of the Continent. They are, however, largely used for heating small halls, churches, chapels, and similar buildings. They are, if well constructed, undoubtedly efficient, but if over-heated, the air is apt to be dried or burnt, and if used for domestic work, they do not play the same part as an open grate in assisting in the ventilation of the room.

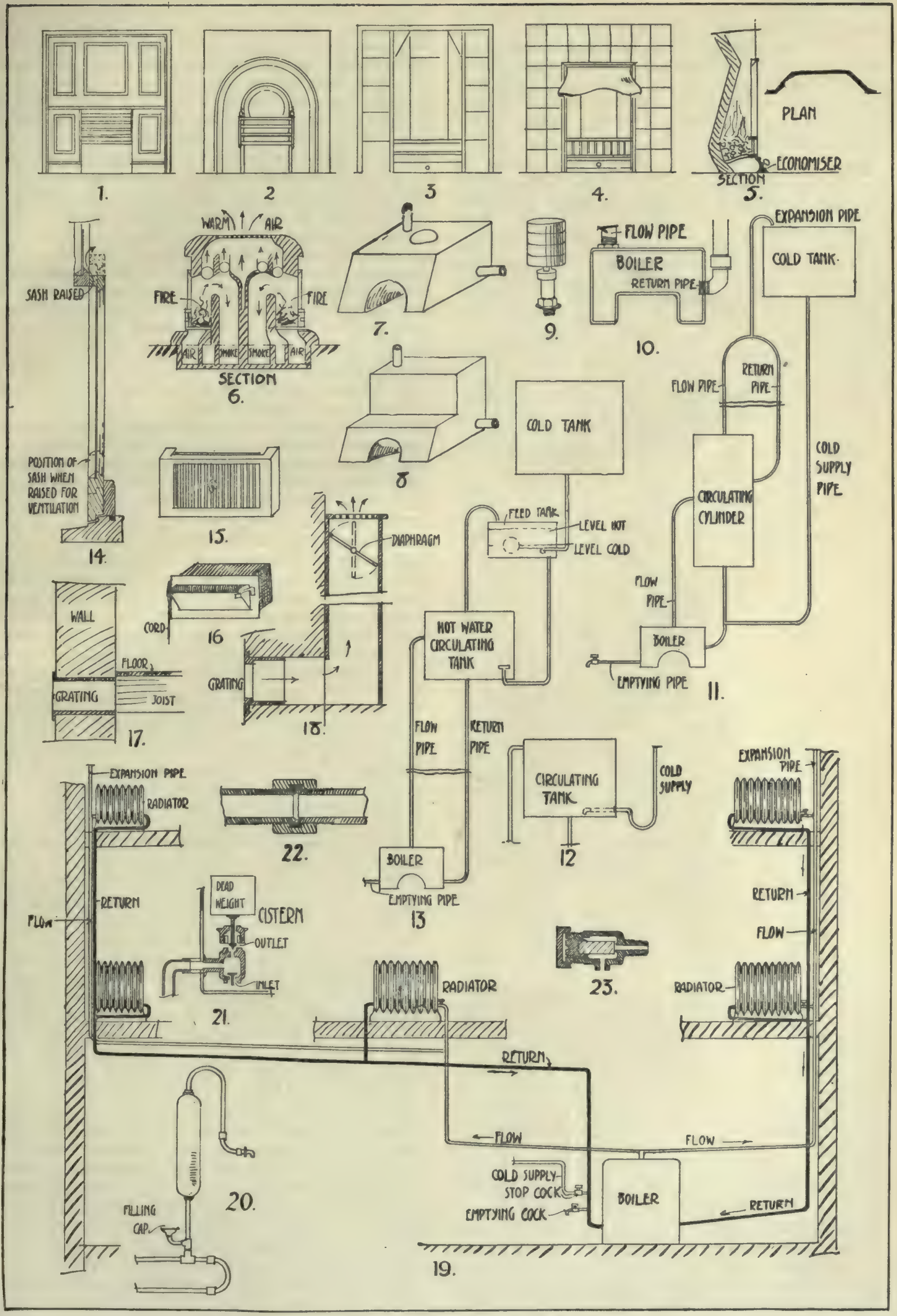
Ventilating stoves are sometimes made, and are provided with air chambers and flues, so as to deliver warmed air into the room, as in the case of a ventilating grate. For hospital use, a special form of stove has been designed, consisting, in fact, of two open fires, placed back to back, so as to stand in the middle of a ward, with chambers and outlets for warmed air [6]. From such a stove, an ordinary chimney is not usually taken, as it would occupy the centre of the ward, but a flue is taken down to the floor level, then horizontally in the thickness of the floor to one of the side walls, with proper provision for sweeping it, and thence vertically above the roof. The fresh air flue is brought in the same way to the stove from one of the external walls.

Heating Water. In these days a good supply of hot water is considered essential, even in houses of quite a humble character; this is usually arranged in connection with a boiler, heated by the kitchen fire, though in larger establishments a specially heated boiler is provided for heating water only.

All hot water distribution depends upon the fact that when heated the molecules of water expand, and become, therefore, lighter, bulk for bulk, than other particles at a lower temperature. These heavier molecules tend to sink to the bottom of any vessel in which the water is contained, forcing the lighter particles to the top, and in any vessel, whether it be a boiler or a pipe, the hottest water is near the upper part of it. If a pipe be inserted in the top of a vessel in which water is heated, and taken to a height above it, and brought back to the top of the vessel, provided the whole is fully charged, the hot water will ascend the pipe in one direction, and be returned to the boiler in the other; but with such an arrangement it is impossible to foretell in which pipe water will ascend, and in which it will descend. If, however, one end of the pipe is connected with the upper part of the vessel, where the water is hottest, and the other is connected to the lower part, the water will invariably ascend by the first and return by the second. This regular circulation is an important element in the success of such an installation if it is intended to supply various fittings with hot water, but it is not a difficult matter to secure. Such a pipe, from the boiler to its highest point, is termed a *flow pipe*, the remainder of the pipe, till it rejoins the boiler, is termed the *return pipe*. It is important in arranging any hot water system to proportion the various parts of the apparatus to each other so carefully that they shall be adequate for the efficient production of a regular hot water supply. Every such system is always fully charged with water, and as soon as hot water is drawn from any tap, an equal bulk of cold water flows in to take its place.

Storage of Hot Water. It is also essential in any such system to provide some means of storing hot water. The boiler, if heated by a kitchen fire, is necessarily of small capacity, and if the water in the boiler and the circulating pipe was all that the system contained, it would be at a very high temperature, but would be very small in bulk. Such a system would very quickly be emptied when water was drawn off from any of the taps. In every system, therefore, a tank or cylinder, capable of holding a considerably larger bulk of water than the boiler, must be provided, but the size of this receptacle must be properly proportioned to the power of the boiler and the fire that heats it. The tank when used is usually fixed above the highest point at which it is required to draw off water, while a cylinder is fixed usually close to the boiler itself, and all draw-off taps are taken from the flow pipe above the cylinder.

The *tank system* [13] is the older form; its chief drawback is that in the event of the cold water supply failing, the tank may be completely emptied by water being drawn off from taps, so that only



HEATING AND VENTILATING APPARATUS

1. Hob grate 2. Register grate 3. Slow combustion grate 4 and 5. Modern grate with economiser 6. Hospital ward stove 7. Saddle boiler 8. Boot boiler 9. Safety valve 10. Connections of flow and return pipes 11. Circulating system with cylinder 12. Connections of pipes to tank 13. Circulating system with tank 14. Ventilating sash 15. Hit-and-miss ventilator 16. Hopper ventilator 17. Ventilation under floors 18. Tobin tube 19. Low-pressure hot-water heating system 20. Expansion tube 21. Combined inlet and outlet valve 22. Joint for high-pressure hot-water pipes 23. Expansion plug

the water in the boiler is left. This may be quickly converted into steam and evaporated, and the boiler left empty. Should this occur, the boiler is liable to become red hot, and to be damaged, and if the water supply is resumed while it is in this condition, an explosion may occur, owing to the sudden generation of steam.

The Boiler. The general arrangements of this system are as follows: the boiler is usually in the form of a *boot boiler* [**8**], or a *saddle boiler* [**7**], and is generally of iron, sometimes of copper. It is set at the back of the kitchen range. The flow pipe is taken from the top of the boiler, and it should be arranged so that its end does not project below the internal surface of the boiler; if it does so project, an air chamber is formed in the top of the boiler, which, though it may not interfere with circulation, results often in somewhat alarming noises in the boiler. The boiler must be provided with a small manhole, to facilitate its examination and cleansing from time to time, and should have fixed to the flow pipe close to it a safety valve, properly weighted, which will allow of any steam generated in the boiler blowing off.

The Circulating Pipe. The size of the flow pipe will depend upon the number and character of the taps that are to be supplied by it. It is taken from the boiler by the route that will most easily bring it near the various fittings it is intended to serve, to the tank, and must ascend gradually the whole of the way; the inclination need not be uniform throughout the length, but should never be less than 1 in. in 10 ft., and it is not desirable that pipes should be so nearly horizontal as this if it can be avoided. The reason for this regular rise is to allow the air, which is contained in all water, and which is driven off when it is heated, a free route of escape; if this is not provided, the air may collect in the pipe and impede or stop circulation. The flow pipe may be taken through the bottom of the tank and is allowed to stand up in it for a considerable distance, or it may be connected through the side at a corresponding level. The reason for this is that the cooler water is at the bottom of the tank, and this arrangement ensures that when a tap is opened, the water drawn from it will be taken from the upper and warmer layer of water and not from the bottom of the tank, with which the inflowing cold supply mingles.

The *return pipe* is taken from the bottom of this tank and is returned by the easiest route to the boiler: and, like the flow pipe, this should never be quite horizontal, still less should it dip at any point. If it enters the boiler at the top, it must be continued inside the boiler, so as to deliver the water near the bottom, or it may be connected to the boiler by a side connection low down. The circulation pipe should be of 1 in. diameter at least, and if the capacity of the tank exceeds 40 gallons, or if more than four fittings are served, it should be $1\frac{1}{4}$ in., and for larger installations even larger.

Branch Pipes. All branch pipes to apparatus such as sinks, lavatories, baths, etc., are taken from the flow pipe, and it is desirable that all such branches should be as short as possible, for the water in them does not circulate, and therefore becomes cold. When the tap is first opened all the cold water standing in the pipe must be drawn off before the hot water begins to flow, and it is desirable to reduce the amount of this to a minimum. The usual sizes of branch pipes are, for lavatories, $\frac{1}{2}$ in.; for sinks, $\frac{3}{4}$ in., for baths, $\frac{3}{4}$ in. or 1 in.

Cold-water Supply. This is an essential feature, and allows of water flowing in from the cold-water cistern to replace immediately any drawn off from the system when a tap is opened. The supply must be arranged so that when water is drawn off only hot water flows from the tap as long as there is any hot water in the system; but without skilful treatment it may easily happen that cold water will find its way to the tap and mingle with the hot and reduce its temperature. The hot-water tank must be fixed at a lower level than the cold cistern, with which it is in many cases directly connected by a pipe; there is no valve between the two systems, but a screw-down stop valve may be very usefully inserted to shut off the supply in case of repairs. In order to prevent any chance of hot water working its way up the supply pipe into the cold cistern, this pipe should have a dip in it at least 6 in. deep just before it enters the tank [**12**]. It may enter the tank through the bottom and be finished with a T-piece to deliver the water horizontally, and close to the bottom, or it may enter the cistern at the side close to the bottom and may then be prolonged inside the cistern and finished with an elbow. The cold-water supply pipe should be 1 in. at least, except for quite small installations.

In many cases, the cold-water supply, instead of being connected with the tank, is carried down and joined to the return pipe just before it enters the boiler. This avoids the introduction of cold water directly into the tank, but it will nevertheless flow back to the cistern if a tap is opened to draw off any considerable quantity of hot water. In some cases a feed cistern [**13**] is provided to supply the hot water system only; this is connected directly with the tank and is supplied by water from the main cistern through a ball-valve. This effectually prevents any return of hot water to the main cistern, but there must be sufficient capacity in the feed cistern above the cold-water line to accommodate the increase of bulk due to heating the water.

Expansion Pipe. From the top of the tank a pipe is taken of the same diameter as the flow pipe, and it is continued upwards to a point not less than 2 ft. above the cold-water cistern; in cases where the boiler is 60 ft. or more below the cistern, this height may be incresed to 3 ft. and in either case the end of the pipe is bent downwards over the cistern. This pipe serves a double purpose—that of an expansion pipe to allow of the escape of water, and that of a vent pipe to allow of the escape of air. The expansion of water, when heated, has already been referred to, and in such a domestic apparatus may amount to from $2\frac{1}{2}$ per cent. to 3 per cent. of the original bulk; if the system is charged with cold water and heat is applied, expansion will at once begin, and if no outlet is provided, at some point it would force an outlet for itself. The water as it expands rises in the expansion pipe and eventually overflows into the cold-water cistern so that no waste of water occurs, and this continues till the water has reached its maximum bulk; normally the water stands in this pipe at the same level as in the cistern. This pipe, which is taken from the highest point of the tank, forms also a means of escape for any air that may collect in it, and if care has been taken to give all pipes throughout the system at least a slight rise, any air given off in the boiler or elsewhere will find its way to the tank and thence escape by the vent.

The Cylinder System. In this system [**11**] the vessel for storing hot water is placed near the boiler, and is, therefore, owing to the head of water,

subjected to a much greater pressure than the tank at the high level; the cylindrical form is therefore selected on account of its strength. The pressure exerted in any case may be calculated by allowing 1 lb. of pressure for every 2 ft. 4 in. of vertical height. The boiler is similar to that used in the tank system, and it is connected to the cylinder with a flow and return pipe; the flow pipe should be connected with the cylinder at a point about two-thirds or three-quarters of its height from the bottom, and, if connected at a lower level, should have an internal pipe added to deliver the water heated by the boiler at this high level. The return to the boiler is taken from the bottom of the cylinder to the lower part of the boiler. The cold-water supply may be brought down and connected to the lower level of the cylinder in the same way as is described for the tank, or it may be connected to the return pipe; it should be of ample size, or the flow of water from the draw-off taps, especially those at a high level, may be checked. A full-way stop valve should be provided in this pipe near the cylinder to facilitate repairs, but there is no other form of valve used. So far, this arrangement corresponds with that of the tank system, except that in this case the boiler and cylinder are very close together; but no draw-off tap is taken from the flow pipe between the boiler and the cylinder. A draw-off cock should, however, be fixed at the lowest point of the return pipe just before it enters the boiler, or in the boiler itself, to facilitate emptying the cylinder and boiler should examination or repairs be required; this should be fitted with a loose handle whi h is kept separate from it to ensure that it is used for no other purpose.

Secondary Circulation. In order to provide the necessary service to the various fittings, a secondary circulation is fitted up from the cylinder; the flow pipe is taken off the top of the cylinder and is carried up as high as may be necessary to serve the highest fitting in the building to which hot water must be taken. From its highest point the return pipe descends to the cylinder and is connected to it at a level above that at which the main flow pipe from the boiler delivers hot water into the cylinder; this arrangement secures that only the hottest water in the cylinder is circulated through this pipe. Though the terms *flow* and *return* are applied to this secondary circulation, draw-off taps may be taken from any point in the circuit, as there is no cold water connection with any part of it. The expansion pipe is taken from the highest point in this secondary circulation to a level above the cold-water cistern, and arranged so as to deliver into it as described for the tank system. As the whole of the taps are connected to the secondary circulation which is above the cylinder, it is impossible that the latter can ever be accidentally emptied.

Conserving the Heat. The efficiency of the system may be considerably increased by surrounding the cylinder, and when possible, the main pipes, with some non-conducting substance; for the cylinder a thick layer of silicate cotton may be employed, kept in position by laggings of wood closely fitted and bound with iron or brass bands, which form a very neat finish. For the pipes, if these are run in pipe casings, they may sometimes be packed in the same manner, or they may be wrapped round with asbestos sheeting; either material prevents the cooling of the pipes to a very great extent and tends to maintain the temperature of the water with but little loss.

Cylinder Tank System. This system is sometimes adopted, especially in large installations, and is essentially the same as the cylinder system, with the addition of a storage tank at a level above the highest draw-off. The advantage of this combination is that with a large body of hot water above the highest tap, there is no danger of the water flowing sluggishly from any of the taps, as happens sometimes in upper floors in the cylinder system; while at the same time there is not the risk ordinarily attending the use of a tank, as the cylinder below renders it impossible to empty the system. But if a large body of water is to be heated and stored, a powerful boiler will be required, and with this system an independent boiler is often useful.

We have considered in some detail the methods of heating ordinary domestic buildings, including the hot-water supply, and must now consider the simpler means of ventilating such buildings, referring afterwards in more general terms to the more complicated systems in use in larger structures.

Object of Ventilation. The essence of successful ventilation is the frequent changing of the air within any building without producing the sensation of movement in the air—that is to say, any perceptible draught. The necessity for ventilation is due to the fact that, as the result of respiration, and also of combustion, carbonic acid gas is produced; if this is present in considerable quantities it acts very deleteriously on the health, producing a sense of discomfort with headache, nervous depression, and liability to disease. Some of this gas is present in the purest air, but normally it does not exceed 4 cubic ft. in 10,000 cubic ft., or 0·4 cubic ft. per 1,000; if the proportion present is increased to that of 6 cubic ft. per 10,000 cubic ft., or 0·6 cubic ft. per 1,000 cubic ft., discomfort at once begins. An adult person exhales as much as 0·6 cubic ft. of this gas every hour, and if in violent exercise even more; if placed in a room 10 ft. square and 10 ft. high—that is, containing 1,000 cubic ft. of pure air—such an adult would in twenty minutes exhale enough carbonic acid gas to raise the total amount present in the air to 0·6 cubic ft., and if this air were not changed and he continued to breathe it, in a very short time it would become so seriously vitiated as to be unsuited to support life. If, however, during the first twenty minutes the whole of the air can be withdrawn and a fresh supply introduced, no such ill-effects will result. This may seem at first a large amount of air to circulate, but a single aperture measuring 5 in. by 12 in. would allow this volume of air to enter within this period with a velocity not exceeding 2 ft. per second, and, under such conditions, no draught would be felt. It will be seen, therefore, that in a room of this size occupied by a single adult, it would be necessary to completely change the air three times every hour to prevent it from becoming perceptibly vitiated, and that, if there was no other means of changing the air, this could be done by means of an inlet and an outlet suitably placed, neither of which need exceed 60 sq. in. in superficies. If two adults were occupying the same room, twice the supply of air would be required per hour, and so on in proportion; the amount of air required per hour is fairly constant, but the number of times the air in any given room must be changed per hour will depend upon its cubical capacity in relation to the number of persons who make use of it.

Fireplaces as Ventilators. In most living rooms the existence of a fireplace ensures that there shall be a permanent outlet to the room. When a fire is burning in a grate this induces a constant

withdrawal of air from the room, which is passed up the chimney, and which amounts to from 3 to 6, or even more, cubic ft. per second, or from 200 to 400 cubic ft. per minute. When no fire is burning in the grate, a current of air may, nevertheless, be set up in the flue, owing to the difference in temperature between the air in the room and the external air, which will suffice, in many cases, to keep the atmosphere adequately changed. It is, therefore, very undesirable, in the case of a register grate, to close the register when the fire is not in use, or, in any other way, to cut off the flue from the room.

Use of Pervious Materials. We have assumed hitherto that the room was hermetically closed except for the special openings for ventilation, but in practice this is not, as a rule, the case. Most of the materials used in building are pervious to air, and when the internal temperature is higher than the external, quite a considerable amount of air may be drawn in through the walls, partitions, and ceilings. In the case of an unplastered brick wall, this may amount to as much as 7 cubic ft. of air per hour for every yard superficial, when the internal temperature is only 1° F. above that of the air outside. Plaster is somewhat less pervious to air, and wall-paper less permeable again, but both allow a very considerable amount of air to pass. If the bricks used have a glazed surface, or if a vertical course of asphalt is fixed in the wall, or if the paper, after hanging, is varnished, the access of air through the portions thus dealt with is practically stopped.

Natural and Artificial Systems. Ventilation systems may be divided into two main classes—*natural ventilation* and *artificial ventilation.* In the latter some mechanical power or specially-arranged heating apparatus is employed to create a movement of air, which is either forced in or drawn out through special channels. Natural ventilation endeavours to make use of the natural laws governing the movement of gases, and to set up and maintain a current of air that will serve to ventilate the building or room to be dealt with. The following points must be noted in relation to this system. Air, like water, expands when heated, and any given bulk of heated air will weigh less than the same bulk of air at a lower temperature, and will tend to rise above it if the opportunity be given for it to do so. Any body of air that is withdrawn from any space by such action is immediately replaced by an equal bulk of air from some other source, but air cannot be introduced by natural means into any given space until room is thus provided for it; when it enters, however, it will invariably do so by the easiest route. If a current of air has once been set in motion in a given direction, it will continue to move in the same direction till forcibly turned aside.

Under most conditions in this country—at least, for the greater part of the year—the temperature within a domestic building is usually higher than that of the external air. Even when fires are not in general use, the presence of at least a kitchen fire, hot-water service, and of human beings, tends to raise the temperature of the air within the building, and the air in any room heated by respiration or combustion tends to rise to the upper part of the room; it will, if it can, escape thence to the upper part of the building, and, as already explained, cooler air will at once take its place.

If an upward current of air can be established in such a vertical pipe as a chimney-flue, the tendency will be for it to continue. Such a current is at once set up when a fire is lighted, but may be set up under other conditions. The difference between external and internal temperatures will often suffice to set up a current of air in such a flue, and any such tendency will be reinforced if, for example, the flue in question is close to another belonging to a fireplace in which a fire is actually burning; but it is, on the other hand, impossible to ensure that a flue which, under certain conditions, acts as an extract may not, under different conditions, act as an inlet.

With a fire burning in a grate the current created is sufficient to ensure the efficient ventilation of any ordinary room provided with a suitable inlet such as is afforded, for example, by a ventilating grate; and at those periods of the year when fires are no longer employed the atmospheric conditions generally allow of ventilation by perflation being freely adopted.

Perflation. *Perflation,* when possible, is an entirely efficient system of ventilating; it consists in providing, in suitable positions, in a room or building a series of openings of large area, usually windows and doors, and allowing the air from outside to pass freely through them. But in this climate such a system cannot be adopted in all conditions of the weather, though it may often be employed as a useful auxiliary. This is especially the case in buildings which are intermittently occupied by considerable numbers of people—for example, school buildings, in which children are, with a view to proper teaching, necessarily collected together in class rooms. In such a room a very powerful artificial system of ventilation would be required to keep it perfectly sweet and free from vitiated air; but in many cases the cost of such a system is prohibitive, and less costly and less efficient expedients have to be resorted to. In such cases, the fact that classes are changed periodically permits of ventilation by perflation being utilised for a short period at fairly frequent intervals.

In a great many cases, little or no attention is given to the ventilation of rooms in private houses, except those of a somewhat superior class. Fortunately, most bylaws require every habitable room to be provided with a fireplace and flue, and an outlet is thus secured, and, as already explained, the action of the fire will ensure air being passed up the chimney from the room, which must be replaced from some external source. A great step in advance is made when the source from which the air is to be supplied is definitely considered and arranged for. Such care not only tends to prevent the existence of draughts in the room, as already pointed out, but should ensure that the air is supplied from the best and purest source available.

Ventilating-sash Windows. It is not always necessary to provide special openings for this purpose, as many modern sash windows are constructed to act as ventilating inlets, and answer admirably, if suitably placed. This is done by making the bottom rail of the bottom sash of extra depth, and providing a deep bead above the sill in the inside [**14**]. The lower sash of such a window may be raised two or three inches without being lifted above this bead, so that air is not admitted at the sill level; but the top rail of the lower sash will be raised, and an opening formed at this point between the lower and upper sash at which air can freely enter, which will be delivered in the room at a considerable height, generally above the level of the heads of the occupants. Such an arrangement will have less tendency to produce a perceptible draught than having the window closed, and letting air force its way in between the sashes and the frame, for it is important to remember that the larger the opening the lower will be the velocity with which

any given volume of air will pass through it in a given time. When, however, there is a considerable difference between the internal and external temperature, if cold air is admitted it is almost impossible even with this arrangement to avoid the sensation of draught.

Special Ventilating Openings. If windows are not made use of, special inlets may be made in the external walls, and provided with fixed gratings externally, and with some form of movable grating or valve internally. Such an opening should not pass straight through the wall from its outer to its inner face, but should be bent upwards in the thickness of the wall.

The external gratings may be of iron or terra-cotta, and are intended to prevent birds nesting in the openings. The internal surface of the flue itself should be smooth, without sharp angles, and may be formed in Portland cement and sand, trowelled, or may be lined with a metal tube. The internal grating may be what is termed a *hit-and-miss grating* [**15**], which consists of two metal plates perforated in identical manner, which allows the passage of air through both sets of openings when they correspond in position; but when one of them is shifted sideways the solid parts of one grating lie over the openings of the other, and either wholly or partially check the passage of air. Many forms of valved gratings are employed; in some a kind of hopper head is allowed to fall forward when air is to be admitted, and is raised again when it is to be closed [**16**]. In others a diaphragm is fixed on a pivot, which can be turned so as to open or close the passage as desired.

Tobin Tubes. Another form of inlet is the apparatus known as a Tobin tube [**18**]; this consists of a short vertical tube, generally about 6 to 7 ft. high, which may readily be inserted in an existing building. It is usually formed of wood, and, if so, must be well framed and glued up, so that the joints are perfectly air-tight; it may have a metal lining, which is generally of zinc. The horizontal sectional area will vary according to the cubical capacity of the room to be ventilated; but the sectional area of the tube, or, if there are several in one room, their united area, should be calculated so as to give, at the very least, 25 sq. in. for every 1,000 cubic ft. of air space. The lower end is connected with the external air, and protected by a grating. Such tubes may sometimes be usefully placed against an internal wall when an air trunk can be taken under the floor or in its thickness to such a position; the upper end is usually open, but covered with a fine grating, and the air is delivered with an upward tendency. Such a tube may be fitted with a diaphragm in its course, so that the opening may be either closed or wholly or partially opened.

Positions of Ventilating Openings. There is much difference of opinion as to the best positions for inlets and outlets, but the general tendency is to place the inlets high up on the wall and the outlets low down, so that noxious gases, as they are produced, do not ascend and collect near the ceiling level, but are withdrawn from the lower parts of the room. It is often advocated that the two openings should be at different levels in the same side of the room, and that this arrangement tends to promote the most complete circulation of air; while others advocate placing inlets and outlets in opposite walls. Much will depend on whether there is only one inlet or outlet in a room, or if there be more than one; in the latter case, it should be possible to avoid any stagnation of air in any part of the room when the inlets and outlets are placed in opposite walls.

An outlet is not infrequently formed into the smoke flue of a fireplace, near the ceiling level, which must be provided with a mica valve, similar to that used in a fresh-air inlet. This will allow air to pass through it from the room into the flue, but will prevent air and smoke passing into the room from the flue.

Ventilating gas burners have been much employed for certain classes of buildings, and less frequently for private houses. In these the heat generated by the combustion of the gas is taken advantage of to create a current of air in a specially arranged outlet tube, which will carry off the vitiated and heated air that will collect in the upper part of a room when no other means of ventilation are provided.

Ventilating Domestic Offices. Before leaving the subject of natural ventilation, it is necessary to point out that it is necessary to ventilate not only rooms used by human beings, but rooms used for preparing and storing human food, and rooms which contain sanitary conveniences. In the case of the latter, it is very undesirable that air should be drawn from them into other parts of the building, though this is usually difficult to prevent. Such chambers are rarely heated, and tend to form a source from which cold air may readily be drawn, as in many cases some permanent opening direct to the external air is insisted upon. Where such chambers are heated, they should be kept at a higher temperature than that of adjoining passages and rooms, the result of which will be that any movement of air that takes place will be into the chamber rather than out of it.

Prevention of Stagnation. Ventilation must also be provided in all positions in which air would tend to become stagnant, especially if there is, at the same time, any tendency to moisture and heat. In the case of a store-room or cupboard having no external window it often suffices to bore two sets of holes, about 2 in. in diameter, one set near the top of the door and the other a few inches above the floor level.

The space under the lowest floor of a building, if the floor is not laid solidly on concrete, is a position in which the importance of ventilation is paramount. If none is provided, the air becomes stagnant, and the timbers are liable to decay from the attack of fungous growths, and from dry rot. It is, therefore, essential that openings be provided in external walls [**17**], and in any cross walls such as will allow of a free circulation of air under all parts of such a floor. Further, as already pointed out [on page 2266], it is important that all hollow spaces formed when walls are built in two thicknesses, and when dry areas are provided, should be efficiently ventilated.

The system of natural ventilation has been described in some detail, as it is the method employed in the large majority of buildings in which any attention is paid to the subject. The more complete systems of artificial ventilation will be briefly described in the latter part of this article, after the various methods of heating on a large scale have been referred to. In both these cases, however, the work is, as a rule, executed by special workmen, under the direction of expert engineers, and this article will not attempt to deal with this part of the subject in the same detail as has been bestowed on the similar systems, the execution of which very usually forms part of the ordinary building contract, and is executed by the general contractor and his workmen.

General Systems of Heating. In those buildings in which for any reason the system of heating by stoves or grates is not suitable, some general system of warming the whole building from a common source is usually adopted. It is possible to employ for this purpose hot water at low pressure, hot water at high pressure, steam, or hot air.

Low-pressure Hot Water. In its essential features this system of heating [19] resembles very closely the system already described for heating hot water for domestic purposes. There is a boiler to heat the water, and a system of pipes through which it circulates, and a tank, not, in this case, closed, but open. The object to be attained in such a system is, however, quite different from that aimed at in arranging a hot-water supply, and the system is consequently modified. It is no longer required to provide a large body of hot water and to conserve its heat, so that it may be drawn out from the system hot; but, on the contrary, it is desired to heat the smallest amount of water that is adequate, to circulate it rapidly, and to disperse the heat through the building. The flow and return pipes are, therefore, often made large (3 in. or 4 in. in diameter), and the storage tank is arranged so that when the water is cold there is only some 2 in. or 3 in. of water in it. It is, however, large enough to hold the additional bulk of water that is created when the water in the system is expanded by heating, and which may amount to about 4 per cent. of the original bulk, for water in a heating system is rust-stained, and cannot be returned to the cold-water cistern; if discharged into the open air by an overflow pipe, there would be sensible loss every time the water was heated. There is, on the other hand, very little waste of water, and a small cold-water service may be used. The supply is regulated by ball valves fixed near the bottom of the tank.

Pipes, Coils, and Radiators. Care must be taken to give a slight rise at least throughout the length of the pipes, but there is not the same amount of air given off from the water after the first heating as occurs in a hot-water service, as in this case only a very small amount of fresh water is introduced into the system after it is once charged. The pipes themselves in some installations form the heating surface, and may be laid in t enches below the floor or fixed above floor level; and they may, if necessary, be arranged in two or three rows to form *coils*; but where additional heating surface is required it is more usual in these days to employ *radiators* [19], which are equally efficient and less clumsy in appearance. In some cases radiators alone are relied on for providing heating surfaces, and the circulating pipes are kept as small as circumstances permit, and are wrapped round with some non-conducting material, so as to keep in their heat.

A radiator is formed of cast iron, and consists of two ends with intermediate sections, of which any reasonable number may be employed, so that the size and heating power of the radiator may be exactly proportioned. The whole set of sections are held together by rods passing through them, which can be tightly screwed up. Each radiator is provided with a small air vent to assist in filling it, and for the escape of any air should it accumulate in the radiator. Each radiator is connected with the flow and return pipe, and these connections should not be so short or rigid as to be seriously affected by slight alteration in the position of their connection with the main flow and return, such as may result from expansion and contraction in these long pipes. Every radiator should be provided with a stopcock, which will allow of its being shut off from the circulation without interfering with any other. The area of heating surface to be provided by this system usually varies from 11 to 20 superficial ft. for every 1,000 cubic ft. of air to be warmed.

Advantages and Drawbacks. Low-pressure hot water is a pleasant form of heating. The surfaces are never so hot as to burn the air, and coils or radiators may be easily arranged for at considerable distances from the boiler. The cost of installation is, however, high, owing to the large size of the pipes, or the large heating surface required in radiators. If installed in a building which is only used intermittently, such as a church or chapel, there is a grave risk in a severe frost that if water is left in the system, the pipes or radiators, and even the boiler, may be burst if the water in them freezes.

Medium and High-pressure Systems. These differ in many respects in principle, as well as in the details of their arrangement, from the low-pressure system. The great advantages are the comparative cheapness of the first cost, and the facility with which the pipes can be carried to different parts of a building, largely owing to their small size; but the heating surface is liable to be raised to a high temperature, and the air may be burnt and rendered very dry.

The system is not an open one, but is absolutely closed, and its successful application is due to the circulation of a very small body of water at a very high temperature. This is rendered possible by the fact that water, though it normally boils at 212° F. at the sea-level, will boil at a much lower temperature at a higher level when the atmospheric pressure is reduced, and, on the other hand, if the pressure is increased, it may be raised to a very much greater temperature without boiling. In this system the expansion pipe is closed; the air contained in it is, therefore, compressed, as the water expands when heated, and exerts a pressure on the water. It is possible, indeed, in some installations to raise the temperature of the water as high as 500° F., and many installations are tested upon completion under hydraulic pressure up to 1,800 lb. or 2,000 lb. per square inch.

Arrangement of Pipes. The pipes used are usually $\frac{7}{8}$ in. internal diameter, with $\frac{1}{4}$ in. thickness of metal, and have a fine thread at each end, one right hand, the other left hand. They are jointed by means of special socket pieces, also provided with corresponding threads, and are screwed up till the end of one pipe, which is cut with an annular chisel edge, is actually embedded in the flat end of the next pipe [22]. Both these ends must be perfectly true and square, and no jointing material is used. The installation, whatever its size, consists of a single endless pipe, made up, of course, of many lengths jointed together. A certain proportion of this is formed into a coil in the furnace, the remainder being taken through the building. In travelling through a very long pipe, the water might lose most of its heat; where the installation is a large one, therefore, it may be divided up into distinct sections. The pipe, when it has travelled through the first section, is returned to the furnace, and an additional length added to the coil; it is again taken off through another section of the building, and again returned as often as may be necessary, but without any break in the continuity of the pipe. A pumping valve is provided near the coil, by which the system is filled, and between the highest point and the *expansion tube* [20] a filling cap is provided for replenishing any waste of water, which, notwithstanding the closed circuit, is bound to occur.

Expansion Tube. The apparatus is filled with water to the level of the filling cap; the expansion tube, which is carefully regulated in size to that of the system, is filled with air, which, when the water is cold, is at normal pressure. When the water is heated, it expands and partially fills the expansion tube, necessarily compressing the air contained within it. The amount of this pressure cannot be exactly regulated, as it depends on the temperature of the water, the bulk of which is increased with the temperature, with the result that the air pressure is also increased. Where it is desired to limit the pressure definitely, and, consequently, the temperature, the expansion tube is replaced by a special inlet and outlet valve placed in a cold-water cistern [21]. The outlet of this valve is closed by a dead weight, which may be regulated to produce any desired pressure in the system, but if this is exceeded, it acts as a safety valve, is lifted, and allows a little water to issue till the pressure is reduced. The inlet is closed by the internal pressure, but as the pressure is reduced the water contracts in cooling, the inlet opens and allows water to enter and replenish the system.

The proportion of the pipe included in the coil varies with the temperature desired, but is usually from one-twelfth to one-tenth the total length of pipe, and the cubical capacity of the expansion tube usually equals from one-ninth to one-eighth of that of the whole of the pipes. The coil is usually surrounded by a furnace built in firebrick, to contain the fire which heats the coil. This is constructed so as to heat the whole of the coil thoroughly.

Steam Heating. *Steam heating* may be advantageously used in buildings in which steam is required for other purposes. This system of heating is usually carried out by means of a main circulating pipe from which branches are taken to steam coils suitably placed for this purpose. One of the difficulties in the application of steam lies in the fact that as heat is given off by the radiators the steam is partially reconverted into water. It is necessary to arrange for the return of this water to the boiler, and to do so in such a way that it will not interfere with the passage of the steam through the pipes. The main circulating pipe is accordingly taken to its highest point directly it leaves the top of the steam boiler, and falls again thence towards the boiler, to which it is connected below the water-level. It should have a minimum inclination of 1 in. in 20 ft. In this manner the water flows in the pipe in the same direction as the steam travels, and does not, therefore, check its circulation. In branch pipes to the radiators, which usually ascend from the top of the main pipe, the inclination should be greater, at least 1 in. in 3 ft., as in this case the water for the short length must flow in a direction opposite to that of the steam, and the pipe should be of large diameter.

The radiators are very similar in appearance to those used for hot water, and must be provided with a stopcock to cut them off from the circulation; but the admission of steam to individual coils cannot be regulated, it must be either full on or quite cut off. Every radiator must be provided with an air vent, as steam cannot enter till any air present is expelled. This is usually fixed at a point about one-third up the radiator, and should be automatic in its action, allowing air to escape when the system is cold and steam is first turned on, and when the steam is turned off, permitting air to re-enter the system to fill the vacuum due to the condensation of the steam. This is secured by using a special valve [23], which may be closed by the expansion of a short rod constructed of a material having a high coefficient of expansion, which will be acted upon as soon as the steam reaches it.

Dips may occur in the circulating pipe, provided that a *drip pipe*—that is, a pipe of small diameter—is taken from the lowest part of the dip to take off any water that may condense and collect there, and convey it to the return pipe. But it must enter this pipe at a point below the water level in the boiler, for, if it were connected above this level, steam might find its way up the pipe and interfere with the proper circulation.

Heating by Hot Air. For certain classes of buildings this form of apparatus is specially advantageous, as it cannot be attacked by frost. It is also inexpensive in first cost, and may be worked economically. The air is, however, delivered at a rather high temperature, and is apt to be perceptible as a current of heated air. The flues distributing the air must have a rather rapid rise, and cannot be carried to any great distance from the furnace. There is some liability also for the air to be unduly dried. This may, however, be corrected by some suitable arrangement for keeping the warmed air moist.

The apparatus consists of a powerful stove, in which the fire is lighted; the stove is of iron, provided with radiating gills, and is erected in a chamber proportioned in size to the power of the furnace. In this chamber the air is heated by the stove, which must be below the level of the apartment to be heated. From the top of the heating chamber a flue, or flues, are taken to deliver air into the hall or room, and these may deliver the heated air at the floor level, as is usually done in churches and chapels, or from openings in the walls at a higher level. Extract flues from the room are brought back to the lower part of the chamber, and in this way the air of the apartment is circulated through the heating chamber, and the temperature is gradually raised. There is also a connection by means of an air duct with the external air, so that fresh air may be introduced into the heating chamber, warmed, and passed into the building when desired. The circulation of air is generally employed, while the temperature of a building is being gradually raised, before it is occupied by an audience or congregation; but when the apartment is occupied, circulation of the air is not desirable, and the fresh air supply is brought into requisition. Some suitable arrangement should be provided for withdrawing the vitiated air at such times, and for this purpose an extract flue with an electrically-driven fan may often be employed.

Artificial Ventilation. *Artificial ventilation* makes use of some special force to create the necessary movement which will change the air either in a large chamber or a building in which a large number of smaller rooms have to be dealt with. In either case there must be several inlets and outlets, and the whole of the outlets must be connected up, so as to be brought under the influence of the force employed, and the inlets must be similarly dealt with if the air is to be forced in. This is done by a series of channels or ducts, formed in brickwork or concrete, or in wood or metal. Whatever materials are used must be impervious to air, or practically so. In the case of wood ducts the joints must be grooved, tongued, and glued up, and they are often entirely covered with canvas glued on and afterwards painted; the internal surface must be smooth, and all changes of direction made by easy bends. It is also important that at all points the sectional area of the duct shall be exactly proportioned to the amount of work required of it at that

point, so that the duct, where it is remote from the central force and is required to convey the air from a single room, is small in area, and is increased with every additional branch flue that is brought into it. All these flues should be contrived so as to be accessible for cleaning.

The Force Employed. The main ducts run nearly horizontally, and in many cases several such ducts from different sections of the building are made to converge at the point where the force is applied. This force may be that of heat, produced by a powerful gas ring in a small installation, or by a furnace or coil of hot water or steam pipes. When any form of heat is employed, a vertical shaft or chimney must be provided to produce a proper draught.

In other cases mechanical power is utilised to drive a fan which shall extract the air by means of the ducts or force it into the building by a similar set of ducts. Such a fan may be driven by steam power if it is available, or by an electric motor, and when used to extract the air, should deliver it into a short, vertical shaft terminating with open louvres on all sides; it should not deliver the air horizontally, in any position where it may be directly acted upon by wind pressure. Such an extract fan may be usefully employed in combination with a hot-air heating apparatus, as already described.

For many installations it is considered advantageous to force the air into a building instead of withdrawing it, and sometimes it is both introduced and withdrawn by mechanical power. The advantages of forcing the air in is that it is possible to select the source from which it is taken, and before introducing it to cleanse and purify the air by passing it through fibrous screens, which filter it and remove all the most noxious particles it contains. It is also possible to regulate its temperature with very great exactness by passing it through a carefully arranged heating chamber before it is introduced into the building and distributed to various apartments. The details of such a scheme necessarily vary with the circumstances of each case, and, as already pointed out, the planning, and, to some extent, the execution, of elaborate systems both of heating and ventilation are in the hands of specialists; but, at the same time, any such system entails much work in the way of preparation and fixing, that comes under the builder's control and management, and which some knowledge of the general system to be used may do much to facilitate.

LIGHTING

The adequate lighting of all parts of a building is a matter of the utmost importance to its comfortable use. The lighting by day is secured by the provision of openings of sufficient size and suitably placed to admit daylight to all parts, and the success of this treatment will somewhat depend on the adequacy of the areas from which light is derived. In towns these are to some extent regulated by Building Acts or Bye-laws, which regulate the height of buildings in streets of various widths, and the extent of open space that must be provided in the rear of such buildings. These regulations are mainly directed to the provision of spaces not wholly inadequate, into which the windows for lighting various rooms may open, and from which both light and air may be obtained. In many cases regulations are also made as to the size of internal courts provided as areas for light. In the case of London, in buildings erected in newly laid-out streets, the provisions are intended to secure that if a line is drawn from the ground level of a building on one side of a street to the eaves or parapet of the opposite building, the angle it makes with the horizon shall not exceed 45°. In the case of a window obtaining light from a court the line drawn from the sill to the eaves or parapet of the opposite wall must not make a greater angle than 62½°, and in the case of the open area at the back, while the angle varies somewhat according to the actual height, the conditions secured are rather better than those in an internal court. These are general rules, modified in the case of buildings irregular in plan, and in the case of buildings laid out in old streets or replacing older buildings destroyed or taken down. All such provisions must be carefully observed, and represent the minimum requirements for towns, and, wherever possible, more favourable conditions should be provided. In particular, an effort should be made to secure that in a domestic building every habitable room should receive at some time in the day not merely daylight but sunshine, which is of the utmost importance from the point of view of health. Darkness, as well as stagnation of air, favours the development of many noxious germs, and it is important, therefore, that not only the habitable rooms, but the corridors, staircases, and the various offices of such buildings should be adequately lighted in every part. In many buildings the conditions governing the place may make it difficult or even impossible to provide for the complete lighting of every part; but it is a consummation to be aimed at and approached as nearly as may be.

Artificial Lighting. Under the conditions of modern civilisation it is absolutely essential, in addition to securing an adequate provision of daylight, to provide some means of artificial illumination, by means of which the various occupations of life may be continued after daylight has failed. At no time has the means of doing so been so complete and efficient as at the present day. Immense strides have been made within the last thirty years, due to the introduction of electricity as an illuminant suitable for domestic lighting. Not only is the light itself admirable from many points of view, but it has stimulated the inventive powers of those interested in gas lighting, and led indirectly to great improvements in this branch of lighting also.

It is not necessary to do more than refer to the older forms of illuminant—candles and oil lamps—as they do not involve any special preparation in the course of the construction of a building, and, in its finishing, only require the provision in some cases of suitable brackets or holders for the lights. But it may be pointed out that lamps certainly have shared in the general improvement, and that both candles and lamps are in many respects pleasant forms of illumination, and must, even in these days, be relied upon by a very large class of householder —by those who live in districts not served by any public gas or electric company, and whose requirements are not sufficient to warrant the establishment of a generating plant for either of these illuminants.

The drawbacks to their use are mainly expense and the trouble of daily attention, and the risk of damage to carpets, furniture, etc., often due to carrying about such movable lights. Such means of illumination are, however, sometimes used to supplement both gas and electric light installations, which are not always carried into every part of a building.

In the case of buildings situated so that there is no public supply of gas or electricity available, it is possible, if the circumstances warrant the outlay,

to establish a private generating station for either gas or electricity, but it is not possible to deal in this article with the details of such installations. It is, however, comparatively rare to find private installations for generating coal gas. Such an apparatus requires skilled attention, and it would be possible to supply gas economically only in the case of a large mansion.

Acetylene Gas. *Acetylene gas* is another form of illuminant that in recent years has come largely into use for such moderate installations; it gives an exceedingly good light, and is, as a rule, less expensive than a gas installation. For an equal amount of illumination the cost is usually estimated as equivalent to that of gas supplied at from 3s. to 3s. 6d. per 1,000 cubic ft. The principal drawback to its use is the extremely unpleasant odour that is apparent if the combustion is not absolutely complete.

The great advantage of such an installation is that it does not require any constant or highly-skilled attention, but may be operated by a gardener, and will not at the outside take more than a few minutes' attention daily. The gas is produced by the combination of calcium carbide and water. Acetylene gas is produced, and lime is left as a residue, and this material is suited for the ordinary purposes of a pure lime. The carbide has great affinity for moisture, and is delivered in sealed metal drums; it must be kept in airtight vessels till used, or it will absorb moisture from the air, and give off its gas. It is necessary to obtain a licence to store carbide in quantities exceeding 5 lb., and such a licence should be procured from the local authority, who examine the store before the plant is fixed. The gas is very inflammable, and may be ignited by any glowing substance, such as tobacco in a lighted pipe, and no form of naked light should ever be introduced into the building containing the plant.

The *plant* includes a *generator*. In this the carbide is brought into contact with the water either by dropping it in by hand from time to time, which is suitable where the plant is large enough to allow of constant attention during operation, or an automatic apparatus is provided for regulating the flow of water over fixed trays of carbide. The gas, when liberated, passes out of the generator into a washer filled with water, which is regularly changed, and which cools the gas and removes soluble impurities. The gas passes thence into an adjustable gasholder, which forms a store, but which, with an automatic generator, is not necessarily of so great a capacity as to contain even one day's supply owing to the facility with which gas is generated. The gas is further purified on leaving the holder, the object being to remove gaseous impurities, and especially phosphuretted hydrogen; this is accomplished by passing it through a substance known as *paratylene*, and from this chamber the supply pipe to the house is taken. A governor to regulate the pressure, which is otherwise variable, is usefully added, and the pipe first descends to a low level, from which it may rise regularly to the house. At the lowest level a small tube or container is fixed to catch any water flowing back from the service pipe, with a tap by which it may be emptied. The supply pipe is usually iron, and copper must not be used for supply pipes or in fittings when it will come in contact with the gas.

Service Pipes. The service pipes are arranged as for ordinary gas supply as already described [page 5797], but the consumption of gas is very much less, and somewhat smaller pipes may be employed. Great care is required in making all joints so as to prevent any escape of the gas, which has a sickly, unpleasant smell, and is, as already stated, highly inflammable. It is usually best to employ steam piping rather than ordinary gas piping, and to see that the screwed joints are sound and made with the smallest possible amount of white lead, as joints that would be perfectly tight when ordinary coal gas is employed will permit the escape of acetylene.

Acetylene Gas Fittings. The fittings used with acetylene gas may be high-class gas fittings or special fittings, the important point being to ensure absolute soundness in the joints and cocks to prevent the smallest escape of gas. The burners are of special form. The holes for delivering gas are very minute, and are arranged so that the gas jets from two holes impinge and produce a flat flame; the burners are arranged on the Bunsen system, so that atmospheric air is mixed with the gas before combustion, and the most recent form of burner, introduced by Messrs. Bray & Co., overcomes a difficulty encountered with most older firms. This was that when a gas flame was turned down the burner was apt to become carbonised, so that it was difficult to use a burner except at full power.

The most usual sizes of burners are the following:

Burner consuming $\frac{1}{4}$ cubic ft. per hour, giving a light of 6·2 candles.

Burner consuming $\frac{1}{2}$ cubic ft. per hour, giving a light of 17·5 candles.

Burner consuming $\frac{3}{4}$ cubic ft. per hour, giving a light of 35 candles.

Hydrogen Gas Fittings. The fittings used for ordinary coal or hydrogen gas were briefly referred to in the article on gasfitting [page 5797]. It is, perhaps, hardly necessary to point out that so far as the form of the fitting and its artistic treatment is concerned there is room for almost infinite variety, and such matters are regulated by individual taste, the money available, and the character of the building in which they are to be placed. But whether the fitting be a bracket or a pendant, fixed or movable, of iron, brass, or copper, plain or elaborate, its main purpose is to provide at a suitable point in some room or hall a burner which will supply gas at a point where illumination is required. The number and disposition of lights, whatever the illuminant, requires careful consideration, and depends greatly on the use to be made of the particular chamber. The following table gives the appropriate amount of lighting that is usually considered requisite for various classes of building, but this is subject to variation in individual cases, and, in particular, if the height of the fitting is varied from the normal position.

This is a matter of considerable importance, for it must be remembered that the illuminating power of any illuminant as affecting any object varies, not according to the distance that separates them, but according to the square of the distance, and if, therefore, lights are fixed at an unusually high level, they must be much more powerful to produce the same effect at the floor level.

Table showing light required for various purposes:

	Per 1,000 sq. ft. area.
County district roads	$\frac{1}{2}$ candle power
Towns (urban)	4 ,,
Cities and boroughs	10 ,,
Dwelling houses (principal room)	250 ,,
Cottages (principal room)	150 ,,
Hospitals	50 to 100 ,,
Schools	300 ,,
Churches and chapels	300 ,,

Gas Burners. The ordinary gas burner is arranged so as to produce a flat flame: the orifice is formed in a very refractory substance, *steatite*, mounted in a brass holder provided with a screw by which it can be attached to any form of bracket or pendant. The commonest form is known as a *bat's wing* burner, and is formed with a thin slit in a cone-like termination from which the gas issues; the *slit union* is somewhat similar, but the termination is spherical. The *union jet* has two small circular perforations from which the jets impinge and form a flat, slightly cup-shaped flame. None of these ordinary forms of burners secure the complete combustion of the gas or the highest amount of illumination from that which is consumed, and they require fairly frequent renewal in order to get satisfactory results; but they are in all cases inexpensive and easily fixed and renewed by the householder himself, without calling in the gasfitter. Such burners are usually protected by glass or china globes, and if placed within 3 ft. of a ceiling or of any woodwork there should be a talc top fixed over the globe, or a glass or metal bell fixed over the light. In public institutions the flame is often protected by a wire globe secured to the fitting, and this is a very useful precaution in the case of any swing bracket which might be swung into contact with any inflammable material.

Improved Burners. An improvement on the simple burner is one fitted with an *economiser*, which is really a second burner of greater capacity, placed over the inner one, producing a larger flame without a greater supply of gas, and securing more complete combustion. Other burners are fitted with some arrangement of governor, by which the pressure at the burner is regulated, though the pressure in the service pipe is subject to fluctuation; there are several varieties of such burners on the market. The *Argand burner* is one arranged to produce a circular flame similar to that produced from the circular wick of an oil lamp; the burner is circular in form with an air space in the centre, and a series of small apertures are formed from which the gas issues, so that a ring of flame is produced; air has access to the middle part of the flame, which is enclosed with a glass chimney, the diameter of which is considerably larger than that of the flame.

Incandescent Burners. The most striking innovation in the use of gas in recent years has been the introduction of what are known as *incandescent* burners, which have, to a great extent, revolutionised gas lighting. In these burners gas is no longer used as the illuminant, but is employed as a heating agent to raise another material to an incandescent condition, producing a very powerful light, and when used in this way the gas may be mixed with atmospheric air, as in an ordinary Bunsen burner, and used to the greatest advantage, with the approximate result that with a reduction of 50 per cent. in gas consumption the illuminating power is doubled. The best known form of burner for the domestic purpose is the Welsbach C. burner; this consists of a burner producing a hot flame of the character described which impinges on a mantle which is suspended directly over it, and which is heated and maintained by the flame in an incandescent condition, producing a brilliant, illuminating surface. The mantles are impregnated with *thorium*, and are somewhat delicate, and their life is uncertain; the burner is also somewhat expensive in the first case, and the maintenance of mantles is a considerable item, but for equal illumination there is, in spite of this outlay, a very great economy in the use of incandescent lighting, as compared with other forms, accompanied by a more complete gas consumption.

An inverted incandescent burner may now be obtained in which all the metal parts of the fitting are above the mantle which, therefore, throws no shadow on a table over which it is placed, and in this respect attains one of the great advantages secured by most electric lamps.

Electric Lighting. *Electricity* has been brought into service as an illuminant, competing with gas, and has many advantages to recommend it, especially for domestic lighting, in which incandescent lamps are almost invariably employed. Some of the principal of these are the great facility with which it is used, the light being turned on and off by the movement of a switch, which greatly conduces to the economical use of the light; the absence of heat and all products of combustion, which in the case of all forms of gas lighting contribute to the vitiation of the atmosphere of rooms, the gradual destruction of decorations, and the blackening of ceilings; the safety from fire where the installation is well-executed, and which is effected by the absence of all unprotected lights and the absence of all use of matches for lighting.

To set against this is the increased cost of electricity over gas for an equal amount of lighting, but this is a matter that depends very much upon the way in which the installation is planned out and used. Very great economies may result from the careful arrangement of fittings and proper provisions for turning on and off the lights in a group separately or in small groups. It should also be borne in mind that while the cost per candle-power is higher in the case of electricity, as compared with gas, it does not follow that the cost per fitting is correspondingly as high, at any rate when comparison is made with an ordinary gas burner, as a very much more brilliant light is often obtained for which a higher price may properly be expected. When the great saving in the cost of redecorating work is taken into account, and a little care is taken not to burn light wastefully, it is found in many cases that the cost of lighting a house throughout with electricity is not very greatly above that of lighting it by gas. Electricity is more readily produced than coal gas in small quantities, and is eminently suited for private installations of moderate size, but the attention of a skilled mechanic is necessary, so that it is not adapted for work of a very small character.

Wiring Buildings. Into the details of the system of wiring buildings it is out of place to enter here, as it is work executed by specially trained workmen, and is not carried out by the builder or his staff; but it is desirable to point out that in the case of a new building, when it is desired that the wires should be buried in the plaster, the special tubes of steel which are used for this purpose, and which are provided with suitable junctions and access points, should be fixed, if possible, before the plasterer's work is executed.

If the wiring is to be carried on the surface of the walls in wood cases hardly any preparation for the electrician can be made by the builder, but he must attend upon him, and cut away plaster, and other work where necessary, and make good.

Electric light fittings show an equal variety in form, design, and cost, as do those for gas, and in the majority of cases these are fixed to wood plates or roses secured to walls and ceilings or to wood plugs concealed, and afterwards covered with metal or earthenware roses or covers.

Continued

DENTAL PLATES

Working in Metal and Vulcanite. Backing the Teeth. Flasking and "Packing." Celluloid and Porcelain Work. Crowns, Bridges, and Springs

Continued from page 5866

THE materials generally used as a base to support artificial teeth in the desired position in the mouth have differed from time to time. The earliest form of denture was carved carefully from a solid block of ivory, either of elephant or rhinoceros tusk. The great skill and prolonged labour requisite, and the consequent expense involved by such truly artistic work, rendered dentures of this nature a luxury accessible only to the few; and, although many specimens which are preserved to this day are remarkable as showing what beautiful work could be accomplished by highly skilled craftsmen, they were necessarily ill-fitting and often of very limited durability.

Working in Metal. The invention of porcelain teeth fortunately afforded at once great possibilities to the dentist, and enabled him to supply artificial teeth to thousands who formerly were forced to dispense with them as best they could. Metal plates were now fitted to the palate and gums, and attached to the platinum pins which had been fused in the substance of the porcelain during the manufacture of the teeth [7, page 5865]. These inventions tended greatly to the benefit of the public and to the advancement of dentistry, but an equally important step in the same direction was made when it was found to be possible to adapt the process of vulcanising indiarubber to the manufacture of artificial dentures. The method of working with vulcanised rubber is described later on, the present description being devoted to the preparation of dentures with metal bases. Models of the upper and lower jaws having been obtained in plaster of Paris, and dried, and dipped in melted stearin, in the manner already described, the next step is to mark with a pencil lines which indicate on the model the shape and size of the metal plate to be used, and the extent to which the palate and gums are to be covered. The model shown in 4 has been marked to indicate the extent suitable in such a case. A pattern of the plate is now obtained by cutting a piece of paper or a thin sheet of lead to the size indicated by the pencil lines, and pressed upon the model. The pattern is then carefully spread out in such a way as to avoid both stretching and tearing, and laid upon a sheet of gold, 18 carats fine, and of No. 7 gauge in thickness for the upper, or No. 9 for the lower. The lower plate being of necessity narrow, many dentists prefer to make it of No. 7 gauge gold, attaching to it by solder an additional plate of No. 5 gauge, which is made to cover the points at which the strain will be greatest. With a pair of strong scissors, known as shears [8], the gold is cut to the size of the pattern, and we proceed to bend and strike it to the desired shape.

"Striking-Up." For this purpose we need the metal dies and counter-dies, the preparation of which has been already described. It is best to reduce with a file the length of the teeth which are standing upon the die in the case of the first die employed, in order to avoid splitting or tearing the gold, an accident which is liable to occur when the plate is first driven towards the shape it is to assume. The gold is then annealed—that is to say, it is heated to a dull red colour in the flame of a Bunsen burner or blowpipe, and then allowed to cool slowly. This important process, which renders the gold for a time soft and tough, and therefore makes it more pliable and less likely to split or tear, must on no account be omitted before any attempt is made to give the plate its proper shape, and should be from time to time repeated during the striking-up process.

The die is securely fixed in a strong vice firmly attached to the work-bench, and the gold plate, being held lightly in the fingers of the left hand in position on the die, is struck by a mallet composed either of horn or wood, which is grasped in the right hand. The first aim of the mechanic must be to drive the plate into the deepest portion of the die, and this in the upper jaw will, of course, be the palate; and when the gold is fairly home in this direction, he will proceed to strike more and more towards the sides, gradually bending the plate over the ridges which correspond in the mouth to the bony margin of the jaw covered with gum. By following this method of procedure, he will avoid the double danger, first, of bending the plate out of shape by blows directed towards the deep parts at too late a stage; secondly, of splitting the plate by force directed against gold unsupported by the die and stretched between two fixed and supported points.

Improving the Fit. When the plate has taken the general shape of the model, and the little tongues of metal have been driven approximately to the places they are to occupy between the teeth, we proceed to improve the fit by resort to the counter-die in addition. The plate is held upon the die, and both are inverted upon the counter-die so that the latter receives the die in the relation in which they were originally cast, the two being, however, now separated by the gold plate [5]. The die is then driven home upon the counter-die, either by striking it repeatedly with a heavy hammer, or, preferably, by placing them between the plates of a powerful press, or swager, as it is called, and gradually closing the latter.

As a result of the striking with mallet and hammer, or the pressure of the swager, the first die and counter-die will have to some extent suffered in accuracy, the mass yielding as a whole, and so spreading out horizontally, and in places being condensed and hardened by repeated blows. These two, therefore, since they no longer accurately represent the plaster model and the mouth, should be abandoned, and the second pair substituted for them. The new die being in turn fixed in the vice, the final fitting of the plate is obtained by striking the little tongues of metal more snugly into their places between the teeth by means of small wedges made of wood, bone, or steel, struck by the mallet. It will probably be necessary to remove a little of the plate in certain places where excess is obvious; this is done by means of files and special nippers, cutting pliers, or shears [8].

The die, with the plate in position, is then again driven home upon the counter-die either by hammer or swager, the third pair being used for the final

fitting of the plate. The latter is now carefully filed to the shape and size indicated on the plaster model.

As a result of the heating and striking of the plate between the dies and counter-dies, the gold will be seen to have lost its lustre, and must be freed from the particles of baser metal which have adhered to it. This object is attained by warming the gold and placing it in a bowl containing hydrochloric acid, which effectually dissolves and combines chemically with the zinc, tin, or lead particles, while leaving the gold uninjured. If it has been decided to employ clasps for the purpose of supporting the plate and teeth attached in the mouth, these should now be made. A clasp is a narrow band of plate gold, 16 carats fine, and of No. 8 gauge, or a length of gold wire, which should embrace a part of the circumference of the natural tooth to which it is to hold the plate in position. Gold so tempered and hammered as to be springy should be employed, and the band should clasp the tooth at its widest part. It is of so much importance that the clasp should fit the natural tooth closely and accurately that it is better to obtain a pattern in sheet-lead in the manner described above, and to use this as a guide in cutting the gold plate to the size required for the clasp. In this manner also unnecessary waste of metal will be avoided. The piece of gold of the required size is then bent to fit closely round the tooth. The bending is effected by means of small pliers, of which a variety should be kept, some having flat jaws, some with one jaw rounded, some with both jaws rounded and having a conical shape [9]. The clasps having been placed in position on the teeth of the model, the metal plate is then fitted to them by filing the plate away where it impinges upon the clasps until it only just touches the latter when accurately in position. With a drop of wax the bands are then attached to the plate, and we may proceed to make this attachment permanent by soldering.

8. DENTAL TOOLS
a. Shears. *b*. Plate nippers. *c*. Perforators

Soldering. Solder for dental purposes is an alloy of gold, prepared by mixing the latter with silver and brass in varying proportions. It is employed in many of the processes of dental mechanics, the purity of the alloy varying in accordance with the purpose for which it is used; but, seeing that in every case the object is to attach two pieces of metal together, it is obvious that a solder whose melting-point is lower than that of either of the metals or alloys to be united should always be employed. The plate and bands being composed of 18 and 16 carats gold, it will be best to use solder which is 14 carats; for, although an expert in the use of the blowpipe is capable of uniting alloys of the same degree of purity, there is always a serious risk of melting the band or plate rather than the solder unless the latter melts at a heat distinctly less than the melting-point of the plate. A suitable solder for the purpose can be made by fusing together 24 parts of gold 18 carats fine, $2\frac{1}{2}$ parts of coin silver, and $3\frac{1}{2}$ parts of brass pins.

In order to keep the clasps closely opposed, and in their right relation, to the plate, it is necessary to surround them with an investing material, which, unlike the wax employed temporarily, is not affected by the heat requisite for soldering. Some fine sand and plaster of Paris, in the proportion of two of the former to one of the latter, is mixed with a little water in the manner described for casting models in plaster. Some of this is placed upon the work-bench, and the plate, with its clasps attached with wax, gently pressed into it, so that the investing material, being carried up the outer side of the clasps, may hold them firmly in position when the sand and plaster shall have set.

The plaster having set, a little boiling water is poured upon the wax to detach it from its position; any exposed points of the clasp which it is important not to cover with solder, or which are in danger of being melted, are painted with whiting; and the surfaces which are to be united are painted with a little borax and water, which will act as a flux and thus encourage the solder to flow to the proper places. The piece of work is then placed upon a suitable wire frame and suspended over the flame of a small gas stove or burner [10]. Slowly heated in this way the uncombined water of the investing material is gradually driven off in the form of steam, and thus prepared, the work may be safely subjected to the fiercer heat of the blowpipe.

To be able to solder successfully with the blowpipe is a somewhat difficult accomplishment, and the young mechanic will find that he acquires the necessary skill only as the result of long practice. The use of the blowpipe plays, however, so large a part in his work that it is of great importance that he should make himself acquainted both with the principles which govern the process and the practical methods of its use. The blowpipe, then, serves a double purpose in that, in the first place, it enables us to ensure a more rapid and complete combustion of the coal-gas employed, owing to the stream of air which becomes mixed with the gas; and, in the second place, it enables us to direct and confine the heat to any small area as may be desirable. The first advantage puts at our disposal a fiercer heat than can be obtained with a simple gas jet or Bunsen burner, while the second enables us to bring about the melting of the solder, and, since properly flowing solder will always run to the hottest points, to carry the solder to the points where it is required.

The Modern Blowpipe. It is becoming more and more common to employ the ingenious mechanical blowpipes controlled by taps and supplied with air by means of the foot-bellows. These possess certain advantages over the earlier methods as well as being much easier to use; but it is important that the young mechanic should acquire skill in the use of the mouth blowpipe, as it not only provides a more thorough training in the soldering process, but also renders him independent of the mechanical blowpipe, which may not always

be available. The mouth blowpipe is a simple pipe of brass with tinned ends gradually tapering towards its point, two inches from which it is bent into a gentle curve, while the end which is to be taken into the mouth should be coated with sealing-wax. A stream of air can thus be directed against the flame of a small gas jet, and a slender and pointed blue flame played upon the metal where necessary. To give the best results, the stream of air should be continuous, and much practice is in some cases necessary before the mechanic can acquire the habit of taking breath in by the nostrils while the cheeks are constantly forcing the air through the pipe.

The Blowpipe at Work. Whether the mouth blowpipe or one of the mechanical forms referred to be employed, the method of procedure is essentially the same. Small pieces of solder coated with borax are placed by means of fine tweezers upon the parts to be united, and the flame of the blowpipe allowed to raise the heat equally throughout. The flame is then directed to the particular points to be soldered, and at first most intensely upon the solder itself. When this is seen to melt, it may be, as it were, drawn by the flame to its proper place, and the flame then suddenly withdrawn. The work is now dropped into a basin to cool it, the investing material removed, and the plate, with its clasps attached, cleansed once more with hydrochloric acid.

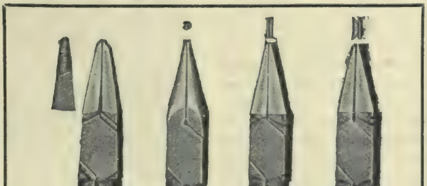
At this stage the plate should be tried in the patient's mouth in order to ascertain whether it fits accurately, and whether the clasps have been attached in proper position. At the same time the dentist ascertains what is to be the relation of the jaws to each other; this process is known as "taking the bite," and will be described at greater length in due course. The dentist at the same time selects artificial teeth suitable to the case, and indicates upon the model the line which corresponds to the middle of the face, as a guide to the mechanic when he sets up the artificial teeth. In the workroom the next step consists of fitting the teeth to the plaster model and backing the teeth.

Backing the Teeth. To effect this, a piece of gold plate 18 carats fine and of No. 5 or 6 gauge is taken and perforated in two places by means of a specially designed pair of perforators [8] in such a way that the two pins of the artificial teeth can be passed through the plate so that the latter may lie flat upon the back of the tooth. In this position the outline of the tooth is marked upon the gold by means of a sharp-pointed steel instrument, and the piece of gold corresponding to these marks carefully cut out with the shears. This piece of gold, which is called the *backing*, is then carefully fitted to the tooth with fine files, so as just to reach the edge of the tooth on all sides, and the edges of the backing neatly bevelled with a file so as to leave the work nicely finished off. The platinum pins are then either bent over or cut short and riveted—that is to say, the points flattened out over the gold—either method resulting in securing the backing to the porcelain tooth.

The teeth backed in this way are now accurately fitted to the model, and the gold plate filed away to accommodate the teeth until the backing and plate just touch when the teeth are in position. They are then secured to the plate with a little wax, and the work again tried in the mouth to see whether the teeth are in proper line and position. Thus connected, the work is again invested, the second investment being brought up over the exposed parts of the porcelain teeth, but leaving the backing accessible to the flame.

When the investment has set and the wax has been removed with boiling water, the work should be very gently heated over the gas-burner, and the needful parts painted with borax and covered with solder, which is then melted with the blowpipe. The greatest care has to be exercised in order to avoid rapid heating or cooling, or strongly heating any part before the whole of the work is thoroughly heated, or the intrusion of any dust or dirt, since any such accident as these is likely to result in the cracking of one or more of the delicate porcelain teeth. The six or eight anterior teeth may be treated in this manner, but for the back of the mouth broad, flat-topped teeth should be used, attached by one or other of two methods.

Obtaining a Good "Articulation." The first method consists of the employment of specially prepared solid porcelain teeth, which are perforated in the middle by a canal lined with platinum. These teeth are fitted down to the plate by grinding them on the lathe, the canal being slipped over a stout gold post, which is secured to the plate with solder. The other method consists in the attachment of shallow porcelain teeth with two outer surfaces only [7] by means of vulcanite. Whichever method be adopted, the broad chewing surfaces of the teeth should be made to correspond to and fit accurately against the teeth of the opposing jaw. This process is described as obtaining a good "articulation." The actual work having been completed, it remains only to smooth and finish the cases so as to render them agreeable and non-irritating to the mouth. This is done by the successive use first of files, beginning with a fairly rough one and passing to smoother as the worker progresses, then of sandpaper, coarse and fine, then of water-of-Ayr stones, which are rubbed on the plate to obliterate fine scratches and file marks, then of pumice and soap, and, finally, of rouge or whiting carried on brushes, which are revolved by means of a lathe.



9. VARIOUS FORMS OF PLIERS

Working in Vulcanite. Vulcanite as a base for artificial teeth offers certain advantages which are sufficient to determine in many cases the dentist's choice in its favour in preference to gold or other metal plates. The fact that the shaping of the metal plates entails the use of dies and counter-dies, obtained from the actual model, of necessity introduces an element of inaccuracy into the work,

since the peculiar changes in shape and size undergone by the metals during heating and cooling must tend to prevent the perfect fitting of the plate.

Vulcanite, as will be seen from the description which follows, is applied in a plastic form to the original model, and hardened in position. One would expect, therefore, that, as a general rule, it would be possible to obtain with it a more accurately fitting base than a metal plate can be; and this conclusion is quite justified by actual experience of the use of vulcanite in practice. Another advantage which vulcanite possesses, and one which renders it especially beneficial to the public at large, is that it demands considerably less skill and the expenditure of less time than is necessary for the manufacture of metal plates. For this reason, and because the material itself is less costly than gold, it is especially adapted for patients who would find the fee charged for a large gold plate prohibitive.

Though distinctly less durable than gold, vulcanite possesses the additional advantage of being more easily altered or repaired; but it is not sufficiently strong to be safely employed when the exigencies of the case demand, as they not uncommonly do, that the base shall be quite thin. The ease with which vulcanite work of an inartistic and inferior kind can be done renders it liable to abuse; but, to employ it to its best advantage, the mechanic should be thoroughly familiar with the details of all the processes involved, and should understand something, at any rate, of the chemistry of this substance and the principles governing its employment.

Preparation of Vulcanite. Vulcanising, then, is the name given to the process by which india-rubber is converted into a hard substance, which is called vulcanite. For dental purposes, india-rubber or caoutchouc is supplied already mixed with sulphur and rolled out into thin sheets for convenience in working. It is generally coloured also by the addition of various substances, such as vermilion (red), vermilion and zinc oxide (pink), or ivory black [7]. It is to the presence of the sulphur that the india-rubber owes the change which takes place when the mixture is heated.

It was at one time generally believed that the change was one purely of physical character, the sulphur incorporated with the rubber melting under the influence of the heat, and, having become thoroughly mixed with the softened rubber, again solidifying when it was allowed to cool. There are, however, good reasons for believing that this is not the true explanation of the change which takes place, and it is far more probable that the process should be regarded as essentially a form of distillation comparable to that by which wood, heated in the absence of air, is converted into illuminating gas, paraffin, pitch, and pyroligneous acid.

India-rubber is composed solely of carbon and hydrogen in the proportion represented by the formula $C_{16}H_7$; when heated in the presence of sulphur, some atoms of hydrogen are separated and combine with the sulphur to form the gaseous compound hydrogen sulphide, represented by the formula H_2S, which possesses the characteristic odour of rotten eggs. The gas becomes dissolved in the water in which the rubber is heated, and can easily be detected after a rubber base has been vulcanised for dental purposes. Vulcanite, which is, therefore, the solid substance resulting from the distillation of caoutchouc in the presence of sulphur and under pressure, is, chemically speaking, of a resinous nature. When properly prepared, it is a solid, firm substance, sufficiently strong to withstand the ordinary force of mastication, but easily cut with files and sharp steel instruments. It is insoluble in water, the saliva, alcohol, and the strongest caustic alkalies, and is only acted upon by strong mineral acids if kept boiling in them for a prolonged period.

The Vulcaniser. It can be softened by heat of the degree of boiling water, and at a still greater heat is combustible, and burns with a strong odour of sulphur. For dental purposes it is found most convenient to heat the rubber in a closed oven, called a vulcaniser [12], of somewhat peculiar shape, which is half-filled with water and heated by means of a small Bunsen burner. Water is used for two reasons: first, because in the form of steam it diffuses and equalises the heat and pressure; and, secondly, because it readily takes up the hydrogen-sulphide gas, which is formed during the process of vulcanising. Should this gas be unable to escape into the water, there is a distinct danger that it will make the vulcanite porous, spongy, and brittle, and so definitely injure it. This is a matter of much importance, and relates chiefly to the subject of the degree of heat and the rapidity of heating required.

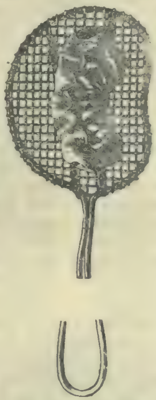
Experience teaches that the complete vulcanisation of rubber takes place most satisfactorily at a heat of about 320° F., and that the heat should be gradually raised to this point. Probably the best results are obtained when the rubber is baked for a prolonged time at different and moderate temperatures, and with this end in view the vulcaniser should be kept for half an hour at 250° F. and 300° F. respectively, and for one hour at 315° F. It is, however, generally inconvenient to allow so much time for the process, and good results are obtained by following the plan more usually adopted. Half an hour is spent in gradually raising the heat to 315° F., and then for one hour and a quarter this heat is steadily maintained. The gas is then turned off, and the boiler allowed to cool, vent being given to the steam which has formed by opening a small pipe controlled by a screw-tap.

Vulcanisers should be strongly made of the best materials, and handled with great care and a strict observance of detail in their management. They should have a safety-plug of soft metal and an accurate thermometer attached to them, or, better still, should be fitted with a pressure-gauge connected with an apparatus for reducing the supply of gas to the burner when the pressure of the steam has attained a force which corresponds to the temperature it is desired to employ—315° F. roughly corresponds to 80 lb. pressure per square inch. In the manufacture of a set of artificial teeth mounted upon a vulcanite base, the first process consists in "taking the bite."

"Taking the Bite." A thin sheet of modelling composition is warmed over the flame of a Bunsen burner or in hot water, and carefully pressed down upon the model, whch has previously been dusted with French chalk to prevent too close adhesion of the composition. The latter is then trimmed off with a hot knife until its margins correspond to the lines upon the model by which the size and shape of the plate have been indicated. Thick blocks of wax are then built up on the composition base along the ridge which is subsequently to be occupied by the teeth. Both upper and lower models having been treated in this manner the composition and wax are gently heated, and the two plates inserted in the mouth, the patient being then instructed to close the jaws together in the natural way. The mid-line of the face having been marked upon the wax as a guide to the mechanic who is to set the teeth in

position, the dentist then removes the two plates with the wax edges adheirng together. These are placed upon their respective models, which, with the wax plates still adhering, are fixed in a hinged apparatus with two limbs, one being for the attachment of each model [11]. There are several varieties of this kind of simple apparatus, called an articulator. When the hinge is opened and closed we have a rough representation of the opening and closing of the mouth, and are thus enabled to place the teeth in such a manner that the two sets shall meet each other as they would in the mouth. The "bite" having been obtained, we proceed to the next process—setting up in wax.

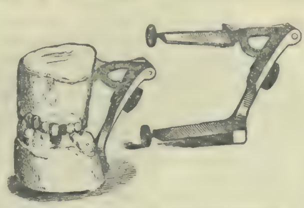
Setting Up in Wax. The wax blocks are removed from the composition plates, and as much of the latter removed as will allow of the artificial teeth being placed in position. Such clasps as may be deemed necessary for the case, having been bent to shape, are attached in proper position to the composition base by wax. Starting from the middle of the mouth, we proceed to fit the two upper central teeth to the model, or, if it is decided to reproduce in vulcanite gum which has been lost, to embed the necks of the teeth in wax placed upon the composition base to the required height. Next, the laterals are placed in position just beyond the centrals, and the canines next to the laterals. As each tooth is fitted to its place platinum pins are bent with fine pliers, and secured to the base with wax.



10. PLATE ON WIRE FRAME TO BE SOLDERED

The six anterior teeth of the upper jaw being set up, we proceed to treat the lower jaw in the same manner, keeping the models in the articulator, and so arranging the teeth that the lower ones close for one third of their depth immediately behind the upper. We thus obtain an imitation of the natural state of things, a scissor-like arrangement adapted to biting off particles of food; and, again imitating Nature, we proceed to place the flat-topped back teeth in such a way that the corresponding teeth of each jaw meet surface to surface to allow of the grinding of food, which constitutes mastication.

The back teeth have been spoken of as "flat-topped" to distinguish them from the sharp-edged teeth in the front of the mouth, but the back teeth really present a number of cusps or prominences on their masticating surface with corresponding depressions, and to obtain an efficient articulation the teeth should be so arranged that cusps fit into depressions in the teeth which oppose them, while the sides of the cusps glide upon one another. Generally speaking, it may be said that the cusps of the upper teeth should fall outside and in front of the corresponding cusps of the lower teeth. The cases set up in this way are nicely finished off by adding wax and trimming away excess with a hot knife, and the dentist then places them in the mouth in order to see that the fit, appearance, and articulation are satisfactory before the cases are finished. Thus corrected, the cases are then submitted to flasking.



11. MODERN ARTICULATOR

Flasking. The flask is a metal box of such a size as conveniently to contain one of the sets of teeth upon its model, which may be reduced in thickness [13]. Several forms are used which differ in some more or less important details. The two main varieties are those composed of three and two parts respectively. The former has certain advantages, the chief of which consists in the fact that with its use there is less risk that the vulcanite will alter its shape while in the boiler. To manipulate it, however, requires rather more time and trouble, and since, with care, good results can generally be obtained with the two-part flask, the latter has remained the favourite with mechanics, largely owing, it is probable, to a natural tendency towards conservatism in methods.

Each set has now to be invested in a flask. For this purpose a quantity of plaster of Paris is mixed in a basin and poured into the lower part of the box, which is composed of two nearly equal parts. The lower part being half-filled with plaster, the set of teeth upon its model is sunk into it, when more plaster is added, until the latter extends to the edge of the flask, and to the margins of the wax and composition. It is then trimmed off smoothly, and allowed to set. When hard it is painted over with a little oil or a solution of soap, which effectually prevents other plaster from adhering. Fresh plaster is then mixed, a portion placed over the case and plaster in the first half of the flask, and the second half completely filled. The two parts are then fitted together, and the whole placed between the plates of a vice or press and driven home, the excess of plaster being, by this method, pressed out from between the two parts.

When the plaster has set, the excess is removed from the flask with a knife, and the flask is then placed in an oven and slowly heated to a temperature approaching that of boiling water. Thus heated a few taps of a wooden mallet upon the sides of the flask will suffice to separate its two parts, since the oil or soap applied as described effectually prevents the adhesion of the two surfaces of plaster, while the heat has melted the wax, which, if firm, might hold the parts together. Boiling water is now poured upon the surface of each half of the flask in order to remove thoroughly the softened wax, and, this being effected, the flask is returned to the oven to be again thoroughly heated. The specially prepared india-rubber for vulcanising is then cut into suitably sized pieces for packing.

Packing. The sheet of india-rubber is, therefore, cut into pieces of a variety of shapes and sizes, which are placed upon the upper surface of a kind of pan containing water, in order that the pieces may be softened, and so capable of being carried to place in the flask.

It follows from the method of flasking the case which we have described that the artificial teeth which were placed in the first or lower half of the flask attached to the composition base by means of wax, will now be embedded—so far as their outer surfaces are concerned—in the plaster of the second or upper half [14]. Here, then, they are held in an inverted position in the roughly horseshoe-shaped curve in which they have been placed, with their backs, from which the bent pins project, facing towards the centre of the flask.

The lower part of the flask contains the model

and presents a duplicate of that part of the palate and jaws which the plate is to cover. When the two halves of the flask are united there remains an irregularly shaped space between the two surfaces of the plaster. This space represents the base in which the teeth are to be supported and embedded; and the object of "packing" is to accurately fill this space with rubber, which can be subsequently vulcanised. The upper part of the flask containing the inverted teeth should be taken first, and, having been carefully heated, is steadied upon the bench with the left hand, which should be protected from burning by means of a thick duster wrapped round the flask. In each hand the mechanic holds a steel instrument called a "packer," with a blunt point or narrow blade as preferred, and with these he places and presses into position the small pieces of heated india-rubber.

The Use of Rubber. Pink rubber should be carefully packed round the necks of the inverted teeth and carried into the cracks which extend down between neighbouring teeth. In these situations pink rubber is used because its appearance is distinctly more natural; in places where the vulcanite will not be apparent red rubber should be employed, as it possesses greater strength than the pink, in which the rubber has to be mixed with two pigments. The pink rubber, therefore, having been packed into such places as demand it, we proceed to tuck small pieces of red rubber around the bent pins of the teeth, in order to securely attach the teeth to the vulcanite base, and to extend the covering of rubber from this point over the parts corresponding to the jaws, and, if the case be intended for the upper jaw, to the palate.

When it is believed that sufficient rubber has been applied, both parts of the flask are again carefully heated, a piece of wet calico laid upon the lower half, and the two halves united and driven home in the vice. On again separating, it appears either that sufficient rubber has not yet been packed upon the plaster, or that too much has already been added. These deficiencies having been corrected, either by adding fresh rubber or by removing the excess by means of a hot knife, little grooves are cut in the plaster to receive any further excess that may be present, and the flask finally closed in the vice and secured by means of bolts fitting into holes with which the flasks are made, or by means of a clamp surrounding the whole flask. The flask is placed in the vulcaniser, which is then half-filled with water, and securely closed with special screws. The gas burner having been lit and placed under the vulcaniser, the process of vulcanisation is carried out in the manner already indicated, and the whole allowed to cool down.

The plaster of Paris undergoes a peculiar change as the result of being heated in this manner in the presence of steam. When the flask is opened the plaster is found to have become a sodden mass, which can be readily broken away from the vulcanite in large pieces, and finally cleaned off with a fine brush. The final process in preparing a vulcanite case consists of filing and polishing.

Filing and Polishing. After vulcanising in this manner, there will be at several points inequalities in the vulcanite and small pieces of rubber in excess which have been pressed out when the flask was finally shut down. These have to be removed, and the case reduced to its proper size and shape by means of files, of which rough ones are first employed, followed by others with finer teeth. The next step is to remove the excess of vulcanite which is found in the spaces between the teeth and around their necks. For this purpose a small tool of chisel shape with a sloping edge is employed, and with this the vulcanite is trimmed off around the teeth until the latter appear with a festooned edge of vulcanite closely resembling the arrangement of the gum and the natural teeth in the mouth. The whole surface of the vulcanite is then scraped with sharp-edged, spoon-shaped steel instruments of various sizes.

Thus reduced to a suitable thickness which gives the case sufficient strength without making it too cumbersome to be worn comfortably, the vulcanite is thoroughly rubbed with sandpaper or glass-paper, a coarse grade being followed by finer grades, and the case is then ready for polishing. For this purpose it is held against a stiff-bristled circular brush revolved upon the head of a lathe, which is worked either by electric power or treadle. This brush is fed with a mixture of pumice-stone and soft soap, and the final gloss is given with a softer brush carrying whiting or rouge. The case, having been thoroughly cleansed with soap and warm water, is then ready to be placed in the mouth of the patient and finally adjusted to the jaws [17]. A new case generally requires some little attention after being worn for a few days before it can be borne comfortably upon the gums, and before the teeth accurately close against those of the opposite jaw.

Gold and vulcanite are the two principal materials employed as a base for the support of artificial teeth, and the main principles which govern the methods of working with these materials having been discussed, it only remains to refer shortly to such other materials as are also used, and the principal modifications in method which their use entails.

Gold and Vulcanite Combined. It is frequently of advantage to construct a denture partly of gold and partly of vulcanite, thus taking advantage of both the strength which the gold confers upon the case and the easy adaptability of the vulcanite. This kind of denture commonly takes the form of a gold plate, to which the clasps and front teeth are attached by solder in the manner already described, while the grinding teeth are attached to the plate by means of vulcanite. To secure the vulcanite a firm hold upon the gold plate, it is best either to solder narrow loops of gold to the plate, or to perforate the latter at several points, leaving the tags of gold thus made as holdfasts. It will be obvious that it will be necessary to complete all the necessary soldering before beginning to vulcanise, since the great heat required by the former process would utterly destroy the vulcanised rubber. This being borne in mind, there should be no difficulty in making such combination dentures. In many cases a narrow strip or length of gold wire placed in the body of the vulcanite while it is being packed will be sufficient to give the requisite strength.

Dental Alloy. Dental alloy is an alloy of certain metals the precise nature and proportions of which are a proprietary secret, but it is known that there is a large proportion of silver and a small quantity of platinum. It possesses two advantages over gold in that it is slightly cheaper and, since it fuses at a higher temperature than gold plate 18 carats fine, it does not require such delicate handling during the soldering process. It is, however, distinctly less durable than gold, and often becomes discoloured in the mouth. Like the alloys already referred to as amalgam filling materials, it is decidedly capricious in its behaviour, and it occasionally happens that such a plate becomes cracked in an unaccountable way, or that a tooth or band is found to be

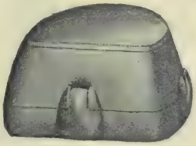
ineffectually soldered. Nevertheless, dental alloy, owing to the advantages mentioned, may be usefully employed in a number of cases. The molar teeth are generally attached with vulcanite.

Celluloid. Celluloid has been employed as a base for artificial teeth, and although it has not been extensively used in this country, and has never been generally popular with English dentists, the mechanic and student should, at any rate, make themselves familiar with the general principles which govern its use for the purpose. The model should be made of the best quality of coarse builders' plaster, and carefully dried so as to be as hard and strong as possible. The case should be set up in wax, flasked, and treated as if for vulcanising.

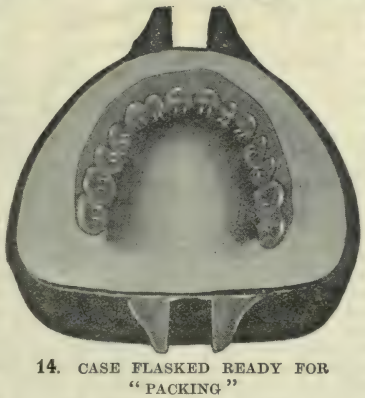

12. VULCANISER WITH PRESSURE GAUGE

A piece of celluloid of approximately accurate size should be softened in hot water and placed in the flask, and the whole gradually heated in a special oven containing dry or moist air, steam, or oil, and fitted with a press which can be gradually closed, thus forcing the softened celluloid into position and pressing excess out into grooves cut in the plaster. Thus made, very slowly cooked and carefully polished, celluloid cases have the advantage of being light, comfortable to the tongue, of good appearance, and clean in manufacture. They are, however, somewhat liable to warp, and do not wear very well.

Porcelain Work. Very beautiful effects can be obtained by reproducing lost gum with fused porcelain of a natural gum shade and markings, in place of the vulcanite or celluloid already discussed. For this purpose it is necessary to employ a plate of platinum as a base, attaching bands with pure gold or gold and platinum as a solder. A narrow strip of platinum is then fitted to the plate, so as to run along the top of the ridge of the jaw, and is attached to the plate by solder at a number of points.


13. VULCANISING FLASK

The porcelain teeth are then fitted in position and the pins so bent as to grip the narrow band referred to, to which they are then soldered. Powdered porcelain is then mixed with alcohol or water, and laid on the plate, care being taken to pack it carefully into the interstices between the teeth and around the pins. The required contour having been in this way built up, the piece of work is then placed in the furnace—the electric furnace preferably as being cleaner and more reliable—and the porcelain carefully dried and then fused. More porcelain is added, and again fused, and, finally, the specially coloured pink porcelain is laid upon the front of the case and carefully carved with suitable instruments, until its surface resembles the natural gum not only in colour but also in form. The case is then finally fused and polished. Such is the most beautiful form of denture which it is possible to obtain, but it unfortunately possesses several disadvantages, the most important of which are its heaviness, its brittleness, and the difficulty in its construction and repair. While dealing with the subject of porcelain, it will be well to refer shortly to the process of fusing porcelain to be inserted into cavities of the natural teeth, as this work is often carried out in the work-room. The dentist takes a small piece of gold or platinum foil, and presses it into the cavity of the tooth until it forms a complete and accurate lining of the cavity. He then withdraws it, and places it with its concavity upwards upon a little platinum tray containing freshly-mixed powdered asbestos and water. Set in this the gold mould is prevented from altering its shape, and may then be filled with a paste composed of powdered porcelain and water, so built up as to restore the lost part of the tooth. The tray and its contents are then placed in the electric furnace, and gradually heated until the porcelain is fused. More porcelain has generally to be added and finally fused. The gold is stripped off, and the porcelain finally trimmed to shape.


14. CASE FLASKED READY FOR "PACKING"

Crowns and Bridges. In dental practice cases are met with somewhat frequently in which one or more teeth are found to be so extensively decayed that the insertion of a durable filling material is out of the question, and choice has to be made between two alternative methods of treatment. Such a tooth may be extracted, or it may be possible to reduce the whole tooth to the gum-level and then attach to the stump which remains an artificial tooth of the shape, size, and appearance of the part which has been lost. When several such teeth remain in the mouth with toothless spaces between them, it is sometimes possible to attach artificial teeth to the stumps and, using them as supports, to attach to them other artificial teeth which fit into the spaces. Single and combined structures of this kind are called respectively crowns and bridges.

A great deal of nonsense appears in printed advertisements which profess to set forth the advantages of this kind of work. These attachments are recommended to the public as "artificial teeth without plates," and attention is drawn to the advantages which these possess as compared with what are described as the "old fashioned" plates. Crown and bridge work has on this account been very much abused.

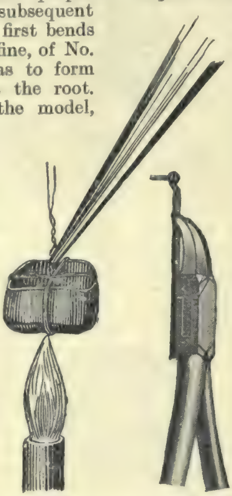
The choice of cases suitable for this kind of attachment and its proper construction demand, perhaps, greater judgment than any other operation in dentistry; and it should be clearly understood that slovenly or unskilful work of this kind, or faulty judgment in selecting cases, is capable of doing more havoc to the patient than almost any other error in carrying out the principles of dental surgery. In the majority of cases the attachment of a crown involves the removal of the nerve and the insertion of a metal post into the canal. This operation, if improperly performed, may cause abscess and even serious disease of the jaw-bone, while many bridges which have been faultily constructed or badly

inserted are utterly insanitary and, in addition, destructive to such natural teeth as remain.

Preparing the Root. In the construction of these attachments the dentist first prepares the root for the reception of the crown. This involves cutting the root with stones until it is cone-shaped and short enough to allow the crown to rest upon it without being in the way of the opposing teeth, and generally also involves the destruction and removal of the nerve. This being effected, he secures an impression of the root in either plaster of Paris or modelling composition, and from this the mechanic prepares a model upon which much of the subsequent work is carried out. The mechanic first bends a piece of metal plate of 22 carats fine, of No. 4 gauge and about $\frac{1}{8}$ in. broad, so as to form a clasp which completely surrounds the root. This, being accurately fitted upon the model, is finally adjusted in the mouth, and the two ends then soldered together with solder of a high grade, 18 carats fine, for instance, to prevent unsoldering during subsequent work. This gold ring, which is called the collar, is then placed in position upon the root and so reduced as to extend evenly all round for about $\frac{1}{16}$ in. beneath the gum, and so as to be clear of the opposing teeth when the mouth is closed.

Some hot modelling composition is then thrust into the collar in position on the root, and the patient directed to close the teeth together. The whole being removed, a model representing the root to be crowned, with the gold collar in position, and a model representing the opposing teeth, can then be obtained in plaster of Paris, and the two held in proper relation to each other by means of a small form of articulator. The next step is to hammer and swage a piece of gold plate into a steel counter-die representing the masticating surface of a natural tooth of similar size to the one to be reproduced. A number of such counter-dies should be kept in stock, representing a variety of shapes and sizes.

The piece of gold thus shaped should have solder 14 carats fine melted into the concavity of the cusps, and then be fitted upon the free edge of the collar. This being effected, the collar is removed from the model, its edge painted with borax and water, then carefully held by means of wire in right relation to the gold cusps, and the whole held in the flame of a Bunsen blowpipe until the two parts are united by solder [15]. When this has been fitted to shape and polished, we have a five-sided, tooth-shaped box or cap which fits over the root, to which it can be attached with cement, a gold or dental alloy post having first been secured in the canal of the root to afford firmer fixation. This form of crown is most suitable for use in the back of the mouth owing to its strength and to the fact that, as it will not be seen, it has not the disadvantage of being unsightly, as would be the case were such a crown inserted in the front of the mouth. In the latter position it is often necessary to sacrifice some strength for the sake of obtaining a natural appearance, and for this purpose a porcelain tooth is fastened to the gold in such a way that the porcelain alone is visible. This involves a considerable modification in the process already described.



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15. GOLD CROWN HELD BY WIRE FOR SOLDERING
16. SWIVEL AND SPRING HELD IN SPECIAL PLIERS

17. COMPLETED CASE WITH SPRING

The collar should be reduced to the level of the surface of the root, and a shallow cap constructed by soldering to it a flat piece of gold plate of No. 1 gauge. Through this are inserted one or more posts which fit into the canal or canals of the root, and are soldered to the gold cap in right position. The next step is to fit a porcelain tooth which has been backed with gold into position upon the gold cap, care being taken that it is short enough to avoid the opposing teeth when the mouth closes. The tooth is then secured to the cap by means of wax, and the whole invested in sand and plaster for soldering, the face of the tooth being carefully covered with an even thickness of the investing material, and the pins and backing and the upper surface of the cap being exposed. These surfaces are then covered with solder, which holds the several parts together. The crown, having been cleansed in hydrochloric acid, and with the pumice brush on the lathe, is ready for insertion.

When a bridge has to be constructed, the supporting crowns are first prepared and placed in position upon the model. Porcelain teeth or metal crowns are then fitted into the spaces between the crowns, to which they are attached temporarily with wax and then permanently with solder.

Repairs and Additions. Artificial dentures are of necessity somewhat fragile, and not infrequently meet with accidents. Of these the most frequent is a fall upon the floor while they are being held in the hand and cleansed. Such an accident as this may result in the fracture of one or more of the porcelain teeth or of the vulcanite, especially in the case of a lower denture, which has the form of an arch, each of the sides acting as a lever when a blow is directed against the extremities. The repair of such injuries does not, as a rule, present much difficulty. A new tooth can be fitted to place, backed and soldered to a plate, or fitted, attached in position in wax, invested, and packed with rubber, which is then vulcanised. It should, however, be remembered that, whereas fresh vulcanite often obtains quite a firm hold upon the old, it is best not to rely solely upon this adhesiveness, but to shape each piece of the fractured vulcanite plate in such a way, by cutting dovetailed slots with a file, that the fragments are held together mechanically by the fresh vulcanite that is added.

Similarly, it often becomes necessary to add one or more teeth to a denture in order to replace natural teeth which have been lost after the denture has been made. This, again, involves no special difficulty, a dovetailed slot being cut out in the vulcanite to allow the new tooth to be fitted to place, and to hold it in position both by adhesiveness and mechanical retention. Where a soldered tooth has

been broken and has to be replaced or has to be added in a fresh place on a denture which carries both soldered and vulcanised teeth, it is generally necessary to remove all the latter before soldering and then replace them with fresh vulcanite. To avoid this lengthy proceeding, it is sometimes possible, when the addition is a small one and is sufficiently removed from the vulcanite, to protect the latter with wet sand, constantly moistened while the soldering is effected.

In order to fit fresh teeth to position, it is generally necessary to obtain a model of the parts. This can most readily be effected by placing the denture in the mouth and pressing a small piece of modelling composition against the gum at the point where the addition is to be made. The denture, with the composition attached, is then removed and placed upon a little mass of freshly-mixed plaster of Paris. When the latter has set and the composition is removed with hot water, we have a representation of the plate in position in the mouth, with a model of the surface of the gum against which the new tooth or teeth are to be fitted.

Addition of Springs. It sometimes happens that, in mouths in which all the natural teeth have been lost, the palate is so flat, or the jaws throughout present so little ridge corresponding with the prominent process of bone which supports the teeth in the natural conditions, that the denture does not adhere firmly to the gums and palate, and suction, due to atmospheric pressure, is so imperfect that the plate falls away from the roof of the mouth. In such cases the dentist must often have recourse to springs, which have been previously referred to. Swivels have first to be fitted to the dentures. The swivel consists of two round bars of gold, about ½ in. in length, connected at right angles to each other by a kind of hinge, which admits of free movement of the one part upon the other so long as they remain at right angles [16]. This form of hinge is obtained by thrusting one bar, which has a flattened head like a pin, as far as possible through the other, one end of which is flattened and pierced to receive its fellow. The headed bar is then secured to the denture either by riveting or vulcanising it in a hole pierced through the vulcanite in the region of the gum between the two bicuspid teeth. Over the other bar is placed one end of the spring. Four such swivels are required, and each is similarly fixed, two on each side of the mouth.

Great care must be taken that the swivels on the same side are suitably placed, the lower one being placed perpendicularly below or in a slightly posterior plane to that of the upper swivel; it is, too, of great importance that the distance separating the swivels should be the same on both sides. The ends of the springs should be screwed down upon three out of the four swivels, as their attachment can then be secured with the least force. In the case of the fourth, any rotation is necessarily impossible, and the swivel must be filed a little smaller, and then the spring pressed over it. By means of these springs the upper and lower dentures move upon each other as upon a hinge, the upper one being supported by them against the roof of the mouth, and the lower one being similarly prevented from sliding upwards and forwards, as there is always a tendency for it to do unless secured by springs [17].

Regulation. Reference has been made to operations and appliances directed towards the correction of mal-placed teeth in the mouths of children. There are fortunately several constant factors which tend to produce a regular and natural arrangement of the teeth, and in many cases an irregular arrangement is due principally to a crowding together of teeth in jaws which, in the course of generations, are becoming progressively smaller. Hence it often happens that the extraction of one or more teeth, by affording sufficient room for the others, allows the natural tendencies to have free play, and so corrects the irregularity.

Sometimes, however, this is not sufficient, and these tendencies have to be assisted by means of appliances which have to be worn in the mouth. Of these, the most usual form is a vulcanite plate fitting the palate and carrying a wire of gold or a length of pianoforte wire, which is bent in such a way as to exert pressure upon such teeth as are in bad position. It is best to employ wire which is springy, as this quality ensures that the pressure shall be moderate in force and gradual.

Gold wire can be made springy by beating it with a hammer, while the springiness of pianoforte wire can be increased by bending it into a single or double coil. This confers an elasticity upon the whole wire which renders it eminently suitable for the purpose. India-rubber bands attached to metal hooks and jack-screws are examples of other methods employed and specially adapted to certain cases. Whatever method is employed, great care should be taken, and trained judgment is required to adjust the appliance so that pressure will act in the direction required. The making of such appliances presents little difficulty. The supporting plate is first made of wax, and the wire fitted to place, and the case then flasked and packed with rubber, which is subsequently vulcanised and polished. It is best to secure a firm attachment of the vulcanite to the wire by roughening the latter with a file, if it is to be of gold, and coating it with tin if it be pianoforte wire. In order to effectually tin the wire, it is best to heat the latter, plunge it first into a solution of zinc chloride, and then into some melted tin.

Tool-making. A capable mechanic should be able to make for himself the majority of the tools which he requires for his work; and, although it may be economical in time to purchase most of the tools in the first place, it will often happen that they will require repairing, adjusting, or adapting to other purposes. He should, therefore, make himself acquainted with the principles involved in the processes known as forging and tempering steel, and acquire skill in the use of the grindstone for the grinding to shape and the setting of sharp instruments. Good tools with a fine edge are a necessity for the proper performance of much of the work of a dental workroom.

For the illustrations in these articles we are indebted to the courtesy of Messrs. C. Ash & Sons, Ltd., and the publishers of "Mechanical Dentistry."

DENTISTRY *concluded; followed by* NURSING

Group 25
ILL-HEALTH
4
Continued from page 5843

DISEASES OF THE BLOOD

Ill-health in the Circulatory System. Cause and Effects of Diseases in the Arteries. Diseases in the Blood Itself. Blood Poisons. The Heart

By Dr. A. T. SCHOFIELD

IN speaking of the ill-health of the circulatory system we must first of all consider diseases of the blood-vessels, then of the blood, and lastly of the heart.

The blood-vessels are, as is well-known, of three descriptions—arteries, which convey the fresh blood stored with food and oxygen to the capillaries; the capillaries, which distribute the food to the body cells through their thin walls, and collect the body refuse; the veins, which return the used-up blood laden with refuse and carbonic acid gas to the heart and lungs to be purified.

ARTERY DISEASES

Atheroma. Atheroma is a hardening and thickening of the arteries, common in old age, and making men prematurely old when it occurs younger in life, as the fruits of excess. It is generally due to alcoholic poisoning, or possibly arises from constitutional weakness. The artery, which should be firm and elastic, like a fresh indiarubber tube, becomes more like one when the rubber is "perished"—that is, hard and brittle. This disease of the blood-vessels often leads to paralysis, and those who suffer from this trouble should be careful to avoid all mental and physical strains.

Aneurism. Aneurism is an expansion or stretching of the wall of some artery from weakness—very commonly the aorta, or the largest artery in the body—so as to make a tumour full of blood, which pulsates or beats synchronously with the heart. Such tumours, if not very large and deeply seated, may exist for years and give no trouble. More commonly they come under the notice of the medical man by accident, and are then treated, often with great success. The idea of these pulsating tumours in the abdomen is a common cause in women of the formation of hysterical tumours, which are formed to resemble aneurisms solely by the unconscious action of the mind on the body. Over fifty such cases came to a London hospital in a very few years.

Embolism. Embolism is the result of the sudden blocking of some small artery, caused by a small solid substance that gets into the blood circulation, often from the breaking off of the end of a clot in some vein. This is swept along in the circulation till it reaches some tiny artery too small to pass, and this it at once blocks, thus cutting off the blood stream from the part the artery supplies. The effects, of course, vary with the part deprived of blood. If it occurs in the brain, we get paralysis (temporary or permanent), with or without loss of speech; if in the lungs, we get sudden breathlessness of an alarming character, and so on. If the clot that blocks the artery is in itself healthy, the trouble is not very serious; but if it is septic, and comes from some ulcer or diseased part, then another abscess will probably form at the spot when the artery gets blocked. The writer has known an embolism in the brain suddenly produced by the incautious massaging of a clot in the vein of a diseased leg.

DISEASES IN THE VEINS

Varicose Veins. Varicose veins, a weakness in the veins, generally of the leg or thigh, is brought on, as a rule, by prolonged standing (not walking) when in a weak condition. A familiar instance of it is found in young shopwomen living largely on white bread and weak tea, who have to stand long hours behind the counter. The reason why standing produces varicose veins and walking does not is this. In walking, the blood circulates quickly, and the muscular action of the legs alternately squeezes and relaxes the large veins, so the blood, by means of the valves they contain, always opening one way towards the heart, is ever moving briskly back from the legs to the body. In standing, all this is reversed. The circulation is slow, and the blood stagnates; the muscles no longer compress the veins so as to send the blood on. So it stands still in the veins, stretching them out in blue knots above each pair of valves, where the vessel bulges, giving the appearance of a chain of black grapes or large currants, just beneath the skin. Cooks, also, standing constantly before a fire, are very liable to varicose veins.

The dangers of this disease are twofold. The vein if large may burst, and severe hæmorrhage, which is very hard to stop, suddenly ensue; or the clot in the vein, called a *thrombus*, may break up, and small portions get into the circulation, with the danger of forming that embolism in any part of the body of which we have already spoken.

Varicose veins are occasionally met with in other parts of the body besides the legs.

Phlebitis. Phlebitis, or inflammation of a vein, forming a clot, or thrombus, is a painful affection with clotting in a vein, which may show no varicosities. Its cause may not so much be standing or sitting as cold or rheumatism, or some other irritant that sets up an inflammation of the veins, which makes it so sticky inside that the blood adheres to it and forms a clot. Of course, if this clot remains healthy, well and good; but if it should become septic, from the entrance of germs, and so on, it is a source of great danger. Large ulcers on the leg may form, which are very difficult to heal. Varicose veins may be protected by an elastic bandage; but in all these diseases of the blood-vessels a doctor must be seen. We must now turn to diseases of the blood itself.

DISEASES IN THE BLOOD

Anæmia. A very common disease in this connection is Anæmia, a pallor of the blood due to the deficiency in the number of the red corpuscles, or to a deficiency in their colour, which is no longer of a bright, vivid red. This pallor and poverty of the blood is readily detected if the inner side of the lower eyelid be turned down and examined, or the inside of the lower lip and gums inspected. The cheeks offer no guide, for many anæmic people have red cheeks, when the colour is fixed, and many without any anæmia have very pale cheeks from the thickness and sallowness of the skin.

We must remember that these red corpuscles carry the fresh air to the tissues, and that in anæmia their numbers and powers are decreased. We are not surprised, therefore, to notice that in anæmia breathlessness is a constant symptom, exactly as if there were some disease of the lungs. We also get some palpitation of the heart and some constipation.

This disease of anæmia is very common in towns, but particularly among those who live indoors, whether in town or country. A woman living indoors in the Highlands is more likely to be anæmic than a flower woman who is ever in the open air in London. Indeed, the roses on the cheeks of these people is a great testimony to the value of outdoor air even in towns.

One form of anæmia, called *pernicious anœmia*, turns the patient the tint of pea-green, and is a dangerous disease, dependent on some change in the nervous system. The best cure is plenty of fresh meat, life in the open air, and iron in small doses.

Leucocythæmia. Leucocythæmia is another disease of the blood, something like anæmia in that it produces great pallor of the blood, but quite different from it in its cause and effects.

It is due, not to a deficiency or defect in the red corpuscles of the blood, but to a great excess of the white, which often rise to ten times their right number. It is connected with serious diseases of the spleen, and is a very grave disease. Fortunately, it is as rare as anæmia is common.

Hæmophilia. Hæmophilia is another blood disease that is often the result of heredity. Those who have it are called "bleeders." The real nature of it is obscure, but it is believed to be some defect in the clotting power of the blood.

It must be understood that if the blood were a simple fluid or liquid like gas or water, as soon as there was a leak or rent in the pipe it would all run away; but in the healthy blood this is prevented by the action of clotting. When there is a cut or a wound of any sort, the blood soon ceases to flow, because when it reaches the air it solidifies into a clot, thus blocking the mouth of the small vessel, and arresting the flow. Now, in "bleeders" the blood does not thus clot. With the slightest wound, therefore, they are liable to bleed to death.

The cause was formerly supposed to be some deficiency in the number of skins the person had, but the real cause is in the blood. The writer has seen a child slowly bleed to death from a scratch on its tongue which could not be healed; and many have died from the simple extraction of a tooth, the hæmorrhage from which nothing would stop.

The condition is a very dangerous one. The late Prince Leopold was affected with it, and those who are subject to it are generally delicate in other ways, and have transparent skins. With care, of course, the bleeding may never occur. These two diseases are serious, and should be seen to professionally.

We now turn to a consideration of blood poisons.

Rickets. This is generally described as a disease due to some deficiency of lime salts in the blood. There is no doubt some poison circulating in the blood of rickety children arising from an excess of starchy or floury food and a deficiency of animal diet. Bad air, darkness, and damp also favour it. Deficiency of lime salts also causes it. Some time ago it was noticed that Glasgow children suffered a good deal from rickets. Then it was discovered that the water had no lime in it. So it was run through beds of lime before it reached the mains which supplied the houses, and the disease soon disappeared.

We must remember that all children are born exclusively animal feeders, and not vegetarians at all. Milk is an animal, not a vegetable, product, and contains a great quantity of nitrogen and those salts that build up bone; hence, strictly speaking, children need more animal food than adults, though not generally in the form of meat.

No child can take any vegetable food at all till it is at least six months old, and not often then if he is kept too exclusively on flour and babies' foods of different sorts. If he does not continue to take a large amount of milk each day, which may be supplemented with porridge, beef-tea, or broth, and, later, with pounded meat, he is likely to develop rickets, and especially if, as well, he has not much fresh air or sunlight. There is a general softening of the growing ends of the bones, and especially in the limbs. The child's wrists and ankles will be found much thickened, as if there were bracelets wound there beneath the skin. A row of knobs may be felt down each side of the breast-bone in front where the ribs join it. The head perspires profusely at night. The legs soon bend and the child becomes bow-legged or knock-kneed; the ribs may bulge and the child's forehead will get square. What is more important, the pelvis often gets deformed, which in women is such a serious matter in child-bearing.

Rickets is often called "the English disease," because, for some reason, it is supposed to be specially prevalent in this country. Meat diet and plenty of fresh air and sun are natural remedies, but if the case is a bad one a doctor should be seen.

Gout. Gout is believed to be due to the poison uric acid circulating in the blood. This blood poison is generally formed from an excess of nitrogenous food, beyond the amount which the liver is able to deal with. There is a "safety

valve" action in the body with regard to excess of this food, which cannot be stored up like sugar or fat; but if the consumption exceeds what can be thus dealt with, instead of the ordinary urates being formed by the tissues, a certain amount of uric acid is introduced into the blood.

Now, the difference between the two—and it is an important one—is this. Urates are easily soluble, uric acid is not; and we have already seen the great danger of circulating solids in the blood, in the case of embolism. Here, however, it is not that the arteries are blocked, but this irritating acid circulating freely in the blood—though a small part of it is taken out of the body by the kidneys, in the form of red sand in the urine—causes heat and pricking in the various tissues, and often uniting with the soda in the blood, forms urate of soda, or chalk-stones, which are deposited where the circulation is sluggish, as in the ear and the small joint at the extremities of hands and feet. These sharp crystals are like bits of glass, so it is no wonder that the agonies of gout are proverbial. These particles are not only deposited in the big toe and elsewhere, but irritate the blood-vessels all along their course, making the walls thicker and giving the heart, therefore, more work to do in pumping the blood through them. Every organ of the body becomes rather more difficult to work as this poison circulates everywhere.

There can be no doubt that if less beer and wine were drunk, and less beef eaten, gout would soon became a rare disease, although, as it is strongly hereditary, it would probably take four generations to remove any tendency to it. Once an attack occurs, it is very apt to recur, and is eventually the cause of an incurable disease. Like most blood poisons, no part of the body, even the skin, remains unaffected. This is a preventable disease, for there is no need, even when there is a predisposition to it, for anyone to have gout. The natural remedies for gout are three or four glasses of hot water drunk daily (not near meals) and careful diet.

Jaundice. Jaundice is the result of bile circulating in the blood. The body all over, and even the whites of the eyes, the tongue and gums turn yellow of a more or less vivid hue. It is caused by the blocking up of the bile duct in various ways, thereby hindering the bile from reaching the bowels, there to be evacuated, and serving in its passage as an antiseptic and a laxative. The results of its getting into the blood are not only that the skin is coloured, but constipation at once sets in, and what is passed is very pale; while at the same time the bile circulating through the kidneys in the blood, the urine is loaded with it, and becomes high-coloured. There is also a feeling of illness, and if the offending cause that blocks the passage be a gallstone, there is agonising pain in the right side below the liver. The most common cause, however, is inflammation of the duct from severe chill, which temporarily closes it. People suffering from this variety soon get well. Laxatives are always required, and hot baths are good.

Diabetes. Diabetes is the circulation of sugar in the blood in such quantities that it is passed by the kidneys into the urine in large amounts, thereby depriving the body of its principal food, and so reducing it to a state of starvation.

The disease is soon recognised; the patient gets thin and emaciated, and craves for water, as the amount of urine is so greatly increased that the body is drained of fluid as well as of nourishment. The skin gets harsh and dry, and there is a sweetish smell perceived. On analysis the urine is found to be doubled or trebled in quantity, and loaded with sugar. When the disease is discovered a doctor must be seen at once.

Rheumatic Fever. It is not proved that rheumatic fever is due to a poison circulating in the blood, but it is not proved that it is not. It may be the work of some undiscovered microbe; theories about it are still legion; but it is convenient to allude to it here together with gout and rheumatic gout.

It is a disease characterised chiefly by agonising pain in the larger joints, acid sweats, and high temperature. It is popularly believed that the acid sweats are Nature's attempts to get rid of the poison, through the skin, that may cause the fever. The poison has been supposed by some to be lactic acid. On the other hand, the temperature looks rather as if Nature were attempting to kill some microbes by heat. It must be acknowledged that we do not at present know the real ætiology, or cause, of this disease.

At any rate, the younger the person is the more dangerous is the disease, for it is then more liable to attack the heart, which is indeed the principal thing to be dreaded. Whereas in the limbs all the effects of the attack pass absolutely away, when the fever is over (in a month to six weeks), in the heart the injury, though not always its effects, are life-long. This disease, together with scarlet fever, are the two most common causes of valvular disease of the heart.

Rheumatic fever seems often to be in part the result of exposure to damp and dyspepsia.

In the limbs it differs from gout in attacking the larger joints rather than the smaller, and in never depositing any chalk stones. Every joint in the body may in turn be attacked by rheumatism, for here, again, it differs from gout, in moving from one spot to another instead of keeping to the same joint.

One bad feature of rheumatic fever is that it tends to return. Sometimes the rheumatism is chronic and lasts for months with no fever or sweating, but with painful and swollen joints. The utmost care is required in the medical care of this disease, and a skilled physician is required.

Rheumatic Gout. In rheumatic gout we get a disease that is as prevalent amongst the poor as gout is amongst the rich, though no law can be laid down, for we find both poor and well-to-do patients martyrs to rheumatic gout.

It is certain, however, that it is caused by poverty, want and exposure. It is very common amongst the poor Irish, and in country places where there is much exposure to cold and damp. It differs from rheumatism in being very chronic

and slowly increasing in severity as it invades and cripples joint after joint. The joints that are attacked are more or less injured by it and seldom get perfectly sound again. They are thickened in some parts, eaten away in others, and often get quite stiff, with more or less pain. There is little fever, but the disease is constantly progressing unless very vigorously opposed. The larger and smaller joints are alike attacked, especially the knees and the fingers, which are bent crooked.

DISEASES OF THE HEART

We must now turn our attention to diseases of the heart. The study should prove both interesting and profitable on account of the advance of our knowledge concerning them.

Palpitation. Palpitation of the heart is a common trouble, and, though it affects the heart, is by no means primarily due to it. To understand its most common cause we must understand the relation of the parts. The stomach is just below the heart, separated from it only by the thin muscle of the diaphragm; so that the heart really sits on the hinder end of the stomach pretty much as a Margate donkey boy sits on the latter end of his ass. The results are similar in both cases. When the donkey is frisky and active, the boy shakes up and down, pretty much in the same way as the heart palpitates on a distended and active stomach. The general cause of palpitation, therefore, is some digestive trouble. "Pain in the heart," too, is really pain from flatulency in the colon, or large bowel, immediately below.

Angina. There is, however, one form of painful spasm of the heart called *Angina*, from which General Gordon suffered all his life. It is of an agonising character in common with all spasms, and cannot be confounded with anything else, especially as the person looks and feels extremely ill at the time of the attacks. The real cause of it is not known.

Fatty Degeneration. The dangerous condition of the heart known as *Fatty Degeneration* is practically wholly preventable, arising as it does from want of exercise, combined generally with too much food. It is dangerous because in it the muscular walls of the heart are partly changed into fatty tissue, and cannot be relied upon to stand the strain of the violent contractions that go on seventy times a minute night and day as the blood is pumped round the system. It is a condition not uncommon in stout elderly people who are too ignorant or lazy to live hygienically.

Weak Heart. A weak heart arises through no disease of that organ, but generally means that if the body be below par the heart shares in the common weakness. The expression is, however, greatly abused, and is an example of the way in which healthy hearts are so often treated as diseased.

This weak heart is often supposed to be the result of a "strain," which requires rest and care, whereas the truth very often is that its "weakness" is really the result of too little exercise. Dr. Goodheart says: "I know of no symptom of a weak heart." Yet, the use of the term leads either to a state of nervous dread, from which recovery is most difficult, or to a life of luxurious idleness, which, by the enervation it causes, is likely sooner or later to lead to the end it seeks to avoid.

Enlargement of the Heart. Enlargement of the heart may be of two kinds; the one is weakening and dangerous, the other is strengthening and safe. They are called *dilatation* and *hypertrophy.*

In dilatation the wall of the heart is circularly stretched and thinned, generally by some over-exertion at a time of weakness. Racing in any form, rowing, running, walking, cycling, may cause it; so do other violent athletic sports calling for great exertion such as "putting the hammer"; so do exhausting sports such as "hare and hounds." It is, of course, as a rule, a preventable condition, though, perhaps, sometimes unavoidable, as, for instance, when a person has a weak heart, for it is certain as long as it exists no further strain should be undergone.

Hypertrophy is the opposite condition, when the heart is enlarged, not by the walls being stretched and thinned, but by the whole organ being enlarged and thickened, so that the heart may in some cases become double its ordinary size. This depends really upon valvular disease.

Valvular Disease. Here we approach a subject of great interest. A man may be practically in good health till he dies from some other cause, at an advanced age, having suffered valvular disease of the heart all his life.

The explanation is this. The heart is a force pump that sends forward four tablespoonfuls of blood at each stroke into the circulation. The blood is prevented from returning by valves, and in rheumatism these valves may thicken at the edge, so that, like a public-house door, they will not quite close. The result is that when the heart contracts only three tablespoonfuls of blood may go forward and one may go backwards. Valvular disease of the heart has thus the effect of causing the heart to do more work. If at all severe the organ may be called to do one-fourth more than the work of a sound heart has to do. This would naturally tax it severely were it not for the *vis medicatrix naturæ*, the force that the unconscious mind uses in presiding over and adjusting the mechanism of every system of the body. In this case the problem is solved simply by making the heart begin to grow again, until it has grown one-fourth larger, and thus do for its size exactly the same amount of work that the smaller sound heart does for its size. This practically restores the person to health, for, the leakage being thus compensated for, it is to all intents and purposes non-existent. Should the leakage, if it exist, fail to be compensated by Nature, we have now means of restoring the heart's power which were utterly unknown a few years ago, so that even in this case there is every prospect of a return of health.

Continued

Group 9
DRESS
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MILLINERY
continued from page 5942

OLD MILLINERY MADE NEW

The Cleaning and Renovation of all Kinds of Millinery Materials: Velvet, Ribbons, Lace, Silk, Flowers, Fur and Feathers. How to Clean Straw and Felt Hats

By ANTOINETTE MEELBOOM

A LITTLE energy exercised in the right direction will often prolong the life of many millinery materials, while, with good taste and a little ingenuity, it is sometimes quite possible to persuade a piece of ribbon, or a length of miroir velvet, for instance, to do double duty. A discarded hat, under the microscopic eye of a clever milliner, will very often be found to possess some shabby ribbon or lace, which needs very little renovation to make it fresh enough to help to trim another hat. We will run through the different materials, and show how they may be simply and effectively renovated.

Velvet. To raise the pile and take out plush marks the velvet must be steamed. First brush and take out all the old threads; then heat the iron and get someone to hold it face upwards. Cover it with a wet cloth, and hold the back of the velvet near the iron over the steam, which, rising through, will raise the pile. Keep the cloth moving to prevent it from scorching and to get sufficient steam. When it has been steamed all over, remove the cloth, and run the back of the velvet lightly over the iron to dry it.

Light-coloured velvets are cleaned by gently rubbing the pile with a piece of velvet which has been dipped in paraffin. If velvet is spotted only, rub on the spots some butter, bacon fat, or olive oil with another piece of velvet. Iron in the same manner as before to raise the pile.

Velvet must never be ironed flat on a table, unless a miroir effect is required. In that case, iron the pile in one direction, when a light, silvery look will be obtained.

Fast-coloured light and dark velveteens, and light velvets which are too soiled for cleaning by the above method, may be washed in a lather of soap made in this manner: shred some soap finely, and let it melt over a fire with just enough water to cover it till it dissolves. Pour as much as will be required in a basin, adding hot water, when a basinful of soapy lather will be obtained. Dip the velvet in it till it is clean, and then hang it out to dry, but do not squeeze it or the pile will be spoiled. Then iron it as directed.

If the velvet is very much soiled, lay it on a table or board and scrub it with a clean brush the way of the pile, till all the dirt has gone.

Ribbons. To renovate velvet ribbon with satin back, hold some tissue paper between the ribbon back and a hot iron, and run the ribbon backwards and forwards over it. If it is badly creased, sponge the satin side with ammonia and water, and iron it in the same way. Get someone to hold the iron face upwards, or pin one end of the ribbon to the table, or something heavy.

Ammonia varies very much in strength. Two teaspoonfuls to one breakfast cup of water is an average proportion.

To stiffen ribbon, put it between two pieces of tissue paper on an ironing blanket. Place a heavy hot iron (No. 8) firmly at one end, and pull the ribbon through. Keep the iron stationary, and repeat until the ribbon is free from all creases. If a very stiff ribbon is required, sponge it after it has been cleaned with gum arabic and water (two teaspoonfuls of gum arabic to ½ pint of water); leave it to dry on a table or board. All ribbons, silks, and laces must be pressed on the wrong side and between tissue paper to prevent a gloss.

To clean black satin and corded ribbon, sponge it with ammonia and water or cold tea. Finish as for stiffening ribbon, drawing the ribbon between the tissue paper and ironing till quite dry.

Miroir velvet should be washed in soap jelly, not squeezed, but hung out to drip and dry. Iron it while very slightly damp in one direction.

To clean ordinary ribbon, scrub it with soapy water, or alcohol and water. Rinse it in several clean waters; do not squeeze it, but hang it out to dry. Finish as before.

How to Clean Furs. Most furs can be cleaned with hot bran. Place a dish of bran in the oven. Heat it right through, and rub it well into the fur; if much soiled, repeat this process, using new, very hot bran. Shake out the fur, and comb it. Sable, beaver, white and pale grey fox, grey astrakhan, and skunk can all be cleaned in this way.

Ermine and other white furs are cleaned with moist bran, rubbed in till dry with a piece of flannel. Then rub it over again with dry, hot bran and magnesia. Shake it well, and comb it. White wool, swansdown, and similar white furs used for children's millinery and pelisses are washed in soap lather, dried, and shaken out before a clear fire. The woolly kinds will want combing as well.

Benzoline can also be used for cleaning light or dark furs. Rub it in with a clean cloth, but be careful not to stand near a light, as it is very inflammable.

To clean ospreys and aigrettes, make a lather of white soap and tepid water. Hold the osprey with the left hand, and pass the first finger and thumb of the right hand from stem to tip. Repeat until quite clean. Rinse in tepid water. To dry it, shake it in the air, or hold it before a clear fire.

Coloured ospreys are cleaned in the same way, but will need dipping again, for which Maypole soap can be used.

White and light feathers and tips are done in the same way, beaten dry on a board which is thickly covered with flannel. Beat them alternately up and down to separate the fibres.

To steam a feather, hold it with its back to the spout of a kettle of boiling water till all the flues are nearly straight. Be careful that the feather does not become quite wet. While still damp, shape the stem, bending the tip slightly, and cut away any irregularity in the flues. Let the feather dry before curling.

Feather Curling. Hold the feather in the left hand, with the outside of the feather towards you. Start curling from the bottom, with a curling knife. If one is not obtainable, use a blunt instrument—a butter or a fruit knife. Take up some flues and gently draw them over the edge of the knife towards you, holding the flues with the thumb and forefinger. Drawing the flues towards you in this way causes them to curl back over the finger. Repeat this all round the feather, curling the tip at the point only. Do not curl the feather too tightly. Practise on an old feather to obtain the knack.

Feathers are imported from Cairo, Tunis, and other parts of North Africa in their rough state, and the mounting of them forms quite a separate trade. Even to curl a feather requires some considerable practice, as there is a tendency to make a curl too tight or not tight enough. Feathers can be had from 8½ in. long to about 27 in. long. Seven or eight of them in their rough state are often put together to make one handsome long one.

Feathers can be bought which are used as an entire trimming of about 1 yd. long. Short feathers are called tips. Feathers that are only slightly out of curl should be shaken before a clear fire. Care should be taken not to hold black ones too near a fire, as they are likely to get a bad colour.

The fashions change in feathers as in all things, and they are either stiffly or loosely curled. Occasionally uncurled feathers are in demand, but these are seldom in favour. Very full-looking feathers have a pass over the stem. In this case the stem is hidden by the flues crossing over it from side to side.

Renovation of Hats. Black and dark-coloured felt hats may be revived by being sponged lightly with diluted ammonia, and some good can be done by ironing it over with a *dark*, damp cloth (not a white one, as the fluff might show on the dark felt). If the crown is softened by a heavy trimming, much stitching, or is damaged by the use of hatpins, it can be brushed with gum on the inside and left to dry on a block or the nearest improvisation of one that can be managed. Do not damp a felt very much before ironing it, as it stretches it considerably. If the felt is a good one, it is well worth having it cleaned professionally.

Felt, flop, and beaver hats may be cut and bent in a great variety of shapes. Cut away the edges with a sharp penknife if the shape is to be reduced in size. Smooth felt flops can be cut away with sharp scissors. The brims can be cut up, a piece taken out, wired round, and from ordinary round flop shapes an innumerable variety of hats, toques, and children's bonnets can be made.

White felt is cleaned with powdered pipeclay. Leave it on for several hours, then heat and shake it out. Stale bread, bran, tissue paper, or a thin paste of magnesia or flour left on till dry and then brushed off, can also be used.

Grey felts are cleaned with hot bran.

Light brown and fawn felts are cleaned with hot fullers' earth or oatmeal.

Velvet hats can be renovated, and quite a new model made, by taking off the crown and making a higher or lower one as may be wished in spatrie or buckram. If the velvet for covering is not sufficient for the new crown, help it out by trimming it with fur or a ruche of ribbon or tulle. A transparent lace crown, made of wire and covered with lace, will look very well. It should be nipped in the headline or, if a larger crown is desired, made separately, and when covered, secured to upper brim.

To alter the brim, unpick the velvet carefully, cut to shape required, bind the edge with folds, and trim. If an enlargement is wanted, sew on wire supports of 1½ in. to 2 in. beyond the brim. Nip on a new edge wire and cover either with lace tulle or chenille laced over and under the wires or any other way preferred. The rest of the brim can again be covered with the velvet, and the effect will be entirely different when finished.

Straw Hats. Straws must be well brushed with a soft brush and the rough kinds with a piece of velvet to quite free them of dust. Steam them before the spout of a kettle filled with boiling water.

Bright black straws may be brushed over with hat varnish, ink and gum, or ink and white of egg.

Fine braid or chip straws with sweet oil mixed with ink. Put it on with a small brush, and rub the hat dry with a piece of velvet. Straw hats may be ironed when not too coarse or fanciful in pattern. Remove all wires, place the brim flat on the table, the crown coming over the edge, with a damp, dark cloth for dark hats, or light one for light straws. Press firmly and slowly with a warm iron round the brim. Iron the inside of the crown carefully. By stretching or contracting while ironing, a shape can be much altered. If, however, it is to be made in an entirely different shape, it must be unpicked and worked up again. Before doing this, see if the straw is worth it, as some break and chip; only very good, soft ones are worth remodelling and occasionally turning.

White straws, if only dusty, can be washed in soap and water. If dirty use a teaspoonful of salts of lemon or a pennyworth of oxalic acid to a pint of boiling water. Scrub the hat. Be careful that the hands have no cuts, as the acids are poisonous. Iron in shape under a white cloth.

White hats may be stiffened with gum water.

The gum arabic should be dissolved in water, diluted with more water till the required stiffness is obtained, and brushed over the hat. Leghorn hats brushed over with white of egg will give a gloss.

Straw hats can be remodelled by steaming. Remove the wire from the edge. Place a damp

cloth over the brim, and when pressing contract or stretch the straw. In this way a flat shape can be made to turn up at the front or sides, and a boat shape or Gainsborough hat can be pressed flat.

To enlarge a straw hat add one or two rows of straw plaits. Headlines may be enlarged by cutting away one or two gussets. To renovate the sides of crowns where the hatpins have cut and worn the straw, sew pieces of straw underneath the weak part. To heighten a straw crown, cut away the crown. Sew one or more rows of straw and sew the crown on again. Other straw may be used, as most likely it will be hidden by the trimming.

How to Clean Flowers and Lace. Good flowers, if only crushed and not faded, may be steamed before the spout of a kettle of boiling water and hung up to dry. When nearly dry, curve the petals with nippers.

Velvet flowers can be steamed, the edges cut and shaped while slightly damp.

Rusty steel ornaments are cleaned by rubbing the ornament on a thick carpet, or rubbing it with brickdust, left to dry, brushed off, and the ornament polished with a leather.

Grease spots on silk may be removed by placing blotting or brown paper on the spot and using a hot iron. Be careful the colour does not fly in the operation.

Lace may be washed in soap jelly and rinsed in cold water. Always iron lace on the wrong side, on a thickly-covered ironing board with the points away from you, and under muslin or tissue paper.

Guipure, Irish, and other similar kinds of lace should be washed in tepid water, shaken, pinned on to a board, and left till dry. It must not be ironed. To tint lace, dip it in weak coffee or tea after rinsing out.

To clean gold lace, sew it up in a clean muslin bag, and boil it in soft, soapy water; then rinse it in cold. If tarnished, apply some warm spirits of wine to the spots. Another method is to clean it with rock ammonia.

To clean silver trimmings, rub it with some finely-powdered magnesia. Leave it for some hours, and then rub it again with a soft rag, and brush out all the magnesia.

Black lace should be brushed with a soft brush or a piece of velvet to get quite clear of dust. Soak it in prepared tea made of one dessertspoonful of tea, two teaspoonfuls of gum arabic, and three pints of boiling water. Iron under tissue paper. Another method to restore the colour of black lace is to soak it for about ten minutes in milk, patting the lace occasionally. Finish as before.

Silk and Crape. White and light-coloured silk must be washed as quickly as possible in a lather of tepid water and soap jelly. Rinse it out twice and use two dessertspoonfuls of methylated spirit to the half-pint in the last rinsing-out water to bring back the gloss. Roll up, iron under muslin with a moderately hot iron. When nearly dry, iron without the cloth.

Coloured silks are washed as described above, but should be rinsed out in cold water in which one tablespoonful of salt and one tablespoonful of vinegar have been added to preserve the colour.

Clean coloured silks with a solution of ammonia and iron when damp.

Wind the crape on a roller or bottle. Tack the edges. Pour boiling water into a large basin. Lay the roll of crape across the basin so that the steam penetrates. Keep the roll moving to prevent it becoming spotty. Do not touch the crape while it is damp. Cut the tacking stitches, and stand it in a warm place to dry. All hats, whether straw, velvet, or felt, should be well brushed after wear, and before being put away.

If of good quality, chiffon renovates very satisfactorily. Wash in soap jelly, rinse in tepid water, do not squeeze or rub. Dab it dry in a clean white cloth, and iron while still slightly damp between a white cloth and tissue paper.

Examinations. The City and Guilds of London Institute hold annually examinations in millinery in two grades—the Ordinary, and the Higher or Evening School Teachers' Certificate.

The first is divided in three sections: (1) Practical; (2) written; (3) specimen work done by the candidate in class or at home. Candidates must pass in the three divisions to obtain a certificate either in the first or second division. Fee, 2s. 6d. for class students; 7s. 6d. for external candidates.

For the practical examination, the candidate must be prepared to do any piece of practical work covered by the syllabus.

The written examination comprises questions concerning various kinds of shape-making, shape-covering and stitches; manipulation of velvet, silk, straw, crêpe, wire; renovations; children's millinery; estimate of quantities and costs; suggestions as to colour and trimmings.

Specimen work varies each year—usually one or two shapes to be copied from a given sketch, and one trimmed hat or toque.

Silver and bronze medals, with money prizes, can be obtained.

To enter for the Evening School Teachers' Examination candidates must be nineteen years of age. The syllabus includes questions on methods of teaching, class management, equipment and arrangement of the rooms, besides questions on the technology of the subject.

A certificate of the Board of Education in either blackboard or freehand drawing is also required. The practical test includes various specimens of candidates' work, some of which can be made half-size. The fee for this examination is £1, and candidates pass either in the first or second division. They must have attended a "recognised training-school" of instruction for not less than 200 hours.

MILLINERY *concluded; followed by* MEN'S HATS

CARVING IN THE FLAT

The Use of the V and U Tools. Flat Carving. Grain Difficulties. Sloping and Rounding the Flat Surface. Diaper Work

WOOD-CARVING continued from page 5811

By F. WELLESLEY KENDLE

WHEN under proper control no tool is more useful to the woodcarver than the parting, or V-tool; until mastered, none other is so dangerous both to the workman and his material; when blunt none so utterly intractable. It is used in four several ways.

Using the V Tool. If working in soft wood, grasp the handle firmly with the right hand, letting the butt rest in the hollow of the palm; seize the blade with the left, knuckles upward; bury one half to two-thirds of the cutting edge in the wood; push it onwards, on an even keel, keeping the same depth, guiding it with both hands, but forcing the blade onwards through the substance of the wood chiefly with the right [29]. Draw a few straight, curved, waved and zigzag lines on a piece of waste wood, and endeavour to follow them with the V, ever keeping the guide-line midway between the *wings* of the tool. Next draw parallel lines at distances varying from $\frac{1}{16}$ in. to $\frac{1}{4}$ in. Cut out the intervening wood, letting each wing of the V just touch a line. Next attempt circles. Beware of giving the tool a list to one side, especially when turning a sharp curve, lest the inside wing should bury itself and splinter the wood; rather press more heavily in the opposite direction. When one vein crosses another, the wood is apt to break away at the junction. Should there appear to be any danger of this happening, start the cross cut from the point of intersection, and work away from it in either direction.

29. POSITION OF HANDS WHEN USING V TOOL

30. USING V TOOL

31. THE MALLET TAP

32. THE PALM TAP

33. BORING "EYES" WITH FLUTER

In a second method, for delicate work, and for negotiating corners and curves, the back of the left hand is rested on the wood, the blade being guided by the thumb and two fingers, while all the pushing is done by the right [30].

Thirdly, if the wood be hard the tool is grasped midway with the left hand, knuckles upward, and driven forward by repeated strokes with the mallet upon the butt of the handle, guiding the direction of the groove and regulating its depth quite as much by the impact of the blow as by the pressure of the left hand [31]

The blows may be given with the open palm of the right hand [32]. For many purposes the rapidity and delicacy of this last manœuvre cannot be excelled.

The Fluter, Veiner, or U Tool. What has just been said about the position of the hands, the employment of the mallet, and the "palm-tap," will apply equally well to the fluter, with one small exception: it is rarely advisable to sink the trough to its full depth with the first cut, unless the carver be an adept and quite certain of his touch; it is far safer to burrow out the hollow little by little, working between double lines.

Set out the border [37] on a strip of deal. Work it with either tool, using the two-handed method.

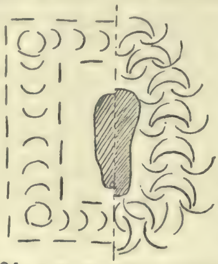
Set out the panel design [35] on a $\frac{3}{8}$-in. oak board, carve it with the V tool and mallet. Try each with the "palm-tap." For making circular hollows with the fluter, split the wood at an angle of 45° at any point of the circumference; continue till the whole circle has been traversed and the loosened chips removed; then, with a single sweep, let the tool re-travel the whole distance, tilting it the while, that one arm may cut away the ridges which were left on its former journeys.

Drilling and Notching. For drilling small holes, such as "eyes" of leaves, hold the fluter perpendicular to the wood, rotating it rapidly between the open palms of the hands, at the same time exercising a slight downward pressure. It is surprising how quickly

a plank an inch thick can be pierced by this little manœuvre [33].

Notching is a favourite style of ornamentation, for which either the U or V are suitable tools [10 or 5]. Drive a perpendicular cut into the wood to a depth of about $\frac{1}{8}$ in., then, re-entering the tool at the required distance from the convexity of the gash, let it sink deeper and deeper until the groove reaches the bottom of the first cut; a slight tilt inwards with each wing of the tool will free the chip.

The Punch. The design can be emphasised by stamping certain portions of the uncut surface with a punch [41]. Hold the punch firmly between the fingers and thumb of the left hand, in such a manner that the lower end of the tool may just free the panel; strike it smartly with the maul, that its pattern may indent the wood; rest the left wrist upon the bench, that it may offer sufficient resistance to enable the tool to recover its position between the strokes. Keep the punch constantly travelling in a haphazard, irregular fashion over the surface, since this gives a much more pleasing effect than if the indentations were parallel to one another. Do not use too sharp a tool—its duty is to punch, not to prick. Plain bands may be embellished with an occasional stamp with a circular, star, or dagger-shaped punch [42]. The keyholes of fifteenth-century chests were sometimes ornamented with patterns punched with the edge of a gouge [34]. Set out the design for an occasional table [36] on a piece of walnut; work it out with a fluter, or U tool, and four-pointed punch.



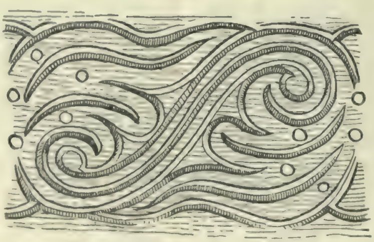
34. GOUGE-ORNAMENTED KEYHOLES

Ambidexterity. When complete command over these tools has been attained, the student should learn to use them left-handed. The ambidextrous woodcarver has a great pull over a man who can only work right-handed; as the run of the grain varies, so can he change his tool from one hand to the other and follow it. In chip carving, especially, the time saved by not having continually to unfasten and refasten his wood, in order to turn it upside down, is very considerable.

Flat Carving. Flat carving consists in cutting away certain portions of the surface of the wood, leaving the untouched parts as a raised design. Transfer the Jacobean panel [48] to a white deal board 24 in. by 11 in. Follow as much of the outline as possible with a carver's knife or skew firmer. Hold the knife in the right hand, the edge of the blade pointing in the direction in which it has to travel. Let the point penetrate the wood to the required depth. If working away from oneself, or from right to left, push it along with the left thumb, guiding with fingers of left, and pulling with the right when in a contrary direction. Avoid cutting against the grain, and follow the course of the arrows. The skew firmer may be used similarly, and with the same precaution [38], or a straight firmer, if it be tilted sufficiently to allow the front point to clear the surface.

35. EXERCISE FOR V-TOOL

36. EXERCISE FOR FLUTER AND PUNCH



37. EXERCISE FOR V-TOOL

If the wood be hard or the design complicated, the outline must be followed by selecting suitable tools to fit its varying contours, these being driven home with the mallet or forced into the wood by throwing the weight of the body forward upon them [39]. Slope the cut slightly outwards from the pattern. Frequently, the margin will be found to present a rounded edge, or to show the ridge where two cuts may have overlapped. The latter may be overcome by selecting gouges of a rather flatter sweep than the convex curve to be travelled, or a trifle quicker for a concavity, and by letting each cut overlap its neighbour; the former, by running a trough with a V tool within $\frac{1}{16}$ in. of the outline. When the firmer or gouge is used later on it will be found that the wood will break away into this, leaving a sharp margin on the other side. Again, when firming in the vicinity of sharp points or weak places, the tool should be entered at a wide angle at some little distance from the outline, then nearer at a lesser angle, and so on, until the dangerous point is reached safely [45].

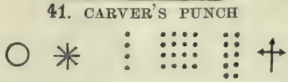
38. THUMBING A FIRMER IN FLAT CARVING

39. FORCING TOOL INTO HARD WOOD

40. USING GROUNDER OR FLAT GOUGE

Difficulties Presented by Grain. Superfluous wood must be removed to a given depth in the intermediary spaces, which is accomplished first with quick gouges, then with flat gouges to further level the floor, and lastly with flat grounders. In doing this, the difficulty of grain will again obtrude itself, for it seldom runs exactly parallel with the surface, but dips either one way or the other, leading the carver to bury his tool too deeply, splintering the wood, or undercutting the pattern. To overcome these dangers, several precautions must be taken. (1) When first fixing the panel on the bench, look at its edges and place it so that the grain may trend upwards from right to left; (2) should it be irregularly wavy, constantly change the direction of the cut to follow its upward curve; (3) use very sharp tools; (4) support the shaft of the blade with the right hand [40]; (5) always work a trifle obliquely to the grain; (6) glide the tool along with an onward and at the same time circular sweep, slicing the wood rather than making an absolutely straight cut through it; (7) make sure that the firming cuts are of their full depth, especially in the neighbourhood of weak places and sharp points.

41. CARVER'S PUNCH



42. FACES OF VARIOUS PUNCHES USED IN WOOD-CARVING

A Much Abused Tool. The *router* [18] is invaluable for rapid grounding. Hold it tightly with both hands and push it backwards and forwards with gradually increased pressure, letting it travel over the entire ground until its flat under surface rests everywhere evenly upon the face of the panel. Finish corners, into which it cannot penetrate, with skew grounders. Most manuals decry the use of this handy little tool in no unmeasured terms. After all, it is the carver's object to remove waste wood, and though it is perfectly right he should learn to do this neatly, with very flat gouges and grounders, there is no reason why he should waste valuable time over an unimportant detail of the work which he can accomplish twenty times more quickly with the use of the router than without it.

When a perfectly level floor has been smoothed out, it may be stamped with a punch to throw up the pattern into stronger relief. It was not an uncommon practice in the fourteenth and fifteenth centuries to paint or gild the ground, afterwards indenting it with geometrical designs or diapers. Occasionally it was left rough intentionally, the contrast with the polished surface of the design answering the same purpose as stamping. By bevelling the top edges of a pattern at a wide angle and slightly undercutting the bottom ones, a pleasing effect of light and shadow, suggestive also of greater depth, is gained.

Sloping a Flat Surface. The next step forward is to slope the flat surface of the pattern. In its very simplest form, folds, turnovers, and interlacements are suggested by a touch of the firmer or V tool; or it is scored with the veiner or V to simulate the veins or irregular margins of leaves; or lowered in places to imitate the appearance of an overlay.

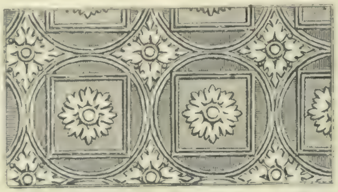
Set out the Jacobean panel [49]. Firm the outline of the outer shield and ground out as before, following the course of the arrows [44]. Now carefully firm the inner shield, lower to $\frac{1}{8}$ in. in its immediate vicinity, then with very flat gouges gradually merge the depression into the flat surface of the design, smoothing finally with broad grounders.

Sink with a flat firmer or gouge at AA to $\frac{1}{16}$ in., then, starting from BB, slope down to the bottom of the cut.

The inner line on the border of the top shield is made either with a tiny V tool or by simply scoring the surface with suitably shaped tools.

Ribbon wavings introduce another modification—namely, rounding on the flat.

Rounding on the Flat. Transfer the design to a panel of white deal [47]. Firm the outline as far as possible with the carver's knife or a skew firmer, following the direction of the arrows.



43. EXAMPLE OF DIAPER WORK

Enter a narrow parting tool at A, let it gradually bite deeper as it follows the sweep of the volute until it reaches B, keeping it thus far upon an even keel. Now tilt it gradually to the left that its right wing may be nearly upright by the time it reaches C. Return to B and tilt to the right, that the other wing may be almost perpendicular at D. Start from these points to firm out the rest of the scroll. Cut E with V tool. F is only half a groove. The ribbon side must be firmed and the slope trimmed down with a very flat gouge. Ground out as before. (In the original panel the ground sinks gradually from the margin, only reaching its maximum depth ½ in. from it as at G.) Sink with a firmer or gouge at HHH, slope down the surface with a wide firmer, merging it into the flat. With suitably shaped gouges make perpendicular cuts in the spiral lines, starting from O. Now attack the ribbon. This can be accomplished in two ways. If the slope be with the grain, sink two perpendicular cuts where indicated, and shave down to the bottom of them with a broad firmer, starting with the blade nearly flat at the crest of the curve and getting more and more upright as it reaches the bottom of the furrow [46]. If the slope be against the grain a macaroni can be used, or a V tool, which, after the first cut is made, can be tilted on one side and made to model down the fold in the ribbon.

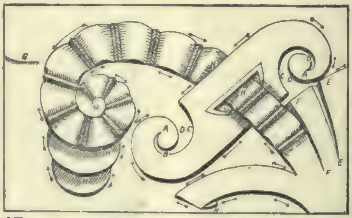
44. THE COURSE OF THE STROKE WHEN GROUNDING

45. STROKES IN FLAT CARVING

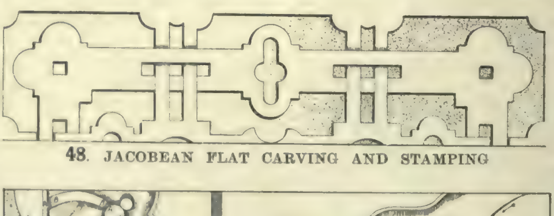
46. ROUNDING ON THE FLAT

Diaper Work. As the name suggests, diapers are series of repeated patterns contained in diamond-shaped compartments resembling the designs seen upon old napery. This style of wood decoration is closely allied to flat carving and can be executed in two entirely different ways. Set out the diaper [43]. Cut perpendicularly along the outline with accurately fitting gouges, etc., next lower the groundwork by hammering with broad, blunt punches, leaving the pattern in relief. The disadvantage of only depressing the ground and not removing it is this: wood that has been compressed will regain its former shape when moistened; thus, hot water spilled on a diaper ornamented tray would obliterate the design. If, instead of punching the ground, the pattern itself be lowered and the whole surface planed level, the design will reappear in relief if the wood be soaked thoroughly, only requiring a touch of the tool here and there to sharpen up the outline. Naturally the relief is low, but this style of work does not readily lend itself to any other treatment. Great care must be taken to punch evenly, that the fibre of the wood may not be injured, for should this occur the pattern would not start up again when required.

Incised Carving. Incised work requires little technical explanation, for its details are similar to those of flat carving, from which it differs in only one particular — the design is formed by the portions removed, instead of by those which are left. To show it up more distinctly colour can be run into the cuts with a fine brush, or they can be filled up with lacquer and the whole scraped perfectly level and polished.



47. JACOBEAN ROUNDING ON THE FLAT



48. JACOBEAN FLAT CARVING AND STAMPING

49. JACOBEAN SLOPING ON THE FLAT

Sculpture d'Applique. Flat and incised carving, as well as diaper work, can be imitated easily by what is called *sculpture d'applique*, or applied overlays. Several thin sheets of wood are superimposed and the pattern fretted out; these pieces are next fixed in the required position with glue, the groundwork punched down and the whole finished by paring down any rough edges that may obtrude themselves too vividly.

Continued

HOW TO SING

Voice Production and the Vocal Organs. Classification and Characteristics of Different Voices. Exercises for Breath Management

By MARY WILSON, A.R.A.M.

IT would not be true to say that a voice can be created or made by a teacher of singing; but all voices, good, bad and indifferent, may certainly be greatly improved and developed by a proper method of voice production.

The First Essentials. It is not enough to sing the melody perfectly and pronounce the words clearly; more than these qualifications are needed. A perfect understanding of the subtleties of a song is required if the listener is to be moved. The student should try to realise, as he sings, how he would feel were the words of the song his own and the outcome of his own feelings.

It is possible for everybody to do this, although in some natures the gift is more developed than in others.

The artistic side of the art of singing, however, should never tempt any singer to neglect or depreciate the technical side of it. It is essential that the æsthetic part of singing should be preceded by a thorough technical study.

First and chief of these is a correct method of breathing. Too great importance cannot be attached to this. Some of the old Italian singing masters used to say that "breathing well meant singing well." Perhaps this is rather an exaggerative assertion, but, at any rate, it is certain that a person cannot sing properly if he cannot breathe properly. It requires diligent and careful practice, but if the student will be advised by a thorough and experienced teacher, he will surely make up his mind at the very beginning to thoroughly master the art of respiration.

Training the Vocal Organs. Having at last so far succeeded in this all-important study, he may then turn his attention to the training of the vocal organs. It must be borne in mind that voice production cannot be forced; it must be developed slowly and surely, or the result will be disastrous.

The study of songs must not be entered upon at too early a date; let the student work at scales, exercises and solfeggi until he is able to sing them without being in the least conscious that he possesses a throat, or, in other words, until his production is perfectly easy. He will then be able to give the whole of his attention to the meaning of the words and the conception of the song, because, through careful, conscientious, and regular practice the technical side of his art will have become "second nature" to him.

It is not the singing voice alone that is benefited; the speaking voice, too, receives a large share of the profits.

Four distinct attributes are essential to musical sound—*Volume, Pitch, Quality,* and *Duration.*

Volume (strong or weak) depends upon the vocal cords, the resonance chambers, and the relative amount of breath pressure.

Pitch (the height or depth of a note) depends upon the number of vibrations in a given time.

Quality depends upon the pharynx principally, together with the cavities of the chest, mouth and head, which act as resonators.

Duration depends entirely upon the breath.

The production of very few voices, either in singing or in speaking, is quite perfect. The voice should be trained in order to make it respond to the will, to make it firm, reliable, strong, and flexible, easy to use, and to ensure correct intonation (to help a person to sing in tune); to point out and correct faults; to understand the art of phrasing; to bring out the various degrees of expression, and to become familiar with the different styles of singing.

How the Voice is Produced. The human voice cannot be described as any particular instrument or thing. To produce it there must be four distinct organs, working together, but quite independent of each other. They are:

THE BELLOWS, properly termed the lungs, together with the wind or breath.

THE VOICE-BOX, properly called the larynx.

THE RESONATOR, properly called the pharynx, together with the mouth and nasal cavities.

THE ARTICULATOR, which consists of the tongue, teeth, lips and mouth.

Given these four requisites, voice can be produced by filling the lungs with air and allowing it to pass out through the mouth. A man, mentally, though probably unconsciously, says he wishes to utter a sound, or to sing; the breath is the motive power, and as it passes from the lungs it travels through numerous tubes until it reaches the larynx or Adam's Apple. In the Adam's Apple, or voice-box, are two ligaments which lie across the throat from front to back. When the order is given for a sound to be produced, these ligaments unconsciously close, and the breath strikes against the edges of them, setting them vibrating or oscillating, and the issue is voice, or sound. The ligaments are generally called the vocal cords or vocal lips.

It requires careful study and much thought to fully understand the parts used in tone-formation.

Naturally it is much more difficult to grasp the principles of singing than of instrumental playing, because the student can *see* the different movements and actions necessary, whereas with the singer much has to be taken for granted.

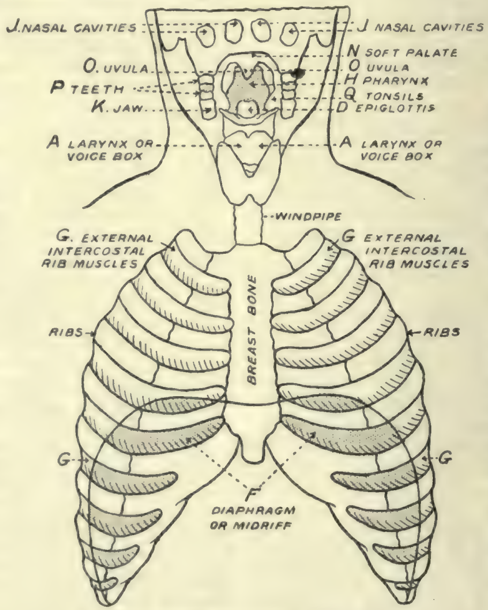
He has to trust chiefly to his hearing—which at best is only an after-effect—for he cannot, except mentally, direct his vocal cords, and certainly cannot see them working. There must, of course, be no trusting to chance. It is very important that he must know exactly what tone and effect he is striving for, and, to acquire these desired effects, it is necessary to know something of the anatomy of the vocal instrument. In order that the student shall not become wearied, the descriptions of the various organs used in voice production are set down as concisely as possible [1 and 2].

The Larynx. The apparatus by which vocal sounds are produced is called the larynx, which is the special organ of phonation. It is placed at the top of the windpipe, immediately under the floor of the mouth. If the fingers are lightly placed on the projecting part in the forepart of the neck, it will be found that, when swallowing, that part moves up and down, and that is the larynx or voice-box, more commonly called Adam's Apple. It is triangular in shape, and open at both ends, top and bottom, so that the breath can pass in and out from the lungs. It is more noticeable in men than in women, and it is easy to see it move up and down as they talk. [1A]

Vocal Cords. Inside the triangular-shaped box, or larynx, are two flat horizontal folds, or cords, which stretch across the throat from the front to the back. These are the vocal cords. It is the greater or less tension of these, together with the breath, that gives us what we know as sound or voice. The higher the pitch of the note, the greater is the tension and more closely together are the vocal cords. [2B]

The Glottis. The space between the vocal cords is called the chink of the glottis. [2C]

The Epiglottis. At the top of the larynx is a self-acting cover, or lid, which is not unlike a bird's tongue to look at. Directly a person wishes to swallow, this little lid, called the epiglottis, shuts down tightly, like a miniature trapdoor, on to the windpipe (trachea), the object being to prevent food from passing into the larynx. Who has not felt the unpleasant sensation of choking when food has gone the "wrong way"? This happens when the epiglottis does not do its work quickly enough. [1D]



1. THE PRODUCTION OF THE VOICE

The Lungs. The lungs, which are two in number, called the right and left, are the bellows of the human body. They are a very spongy and elastic tissue, and may be likened to two sponges. They are capable of great expansion and contraction, and are placed, or, to be more correct, suspended in the upper part of the body, which is called the chest (thorax). They are connected to the windpipe by two tubes, which divide and subdivide until the size of the smallest pipe, if such it can be called, is about the fortieth part of an inch long. At the end of each tube, or pipe, is a minute air-cell. In the chest, which is an air-tight compartment, the lungs and the heart fit quite closely. The floor of the chest is known as the diaphragm, of which more will be said later. The walls or sides are formed by the ribs, together with the breast-bone. [2E]

The ceiling, or top, is formed by the ribs, collar-bone, and the root of the neck. The lungs rest, as it were, on the diaphragm. The size of the lungs depends entirely upon the size and build of the body. Their colour is a kind of purple, or rather dark bluish red. Their chief work is to supply the blood with pure air and to free it from carbonic acid; it is quite necessary therefore always to breathe fresh air.

The Diaphragm or Midriff. The largest muscle in the body is an involuntary one, called the diaphragm, or midriff. It divides the upper part (the chest) from the lower (the stomach); that is, it lies across the body. The outer parts are fixed to the lower ribs.

When the lungs are almost empty, or, in other words, during the act of exhalation, the diaphragm is almost dome-like in shape. As the lungs fill with air they press on the diaphragm until it becomes much flatter in appearance. Only will power can control this huge muscle, and, as it plays such a very important part in the art of respiration, the student cannot be too diligent in his endeavour to mentally control it. [1F].

The Rib Muscles. On each side of the chest there are twelve ribs, making twenty-four in all. Each is connected with the backbone or vertebral column; they curve round to the front, and seven pairs, counting downwards from the neck, are joined to the breast-bone;

the eighth, ninth and tenth are joined to the seventh, whilst the eleventh and twelfth pairs are not attached to any part in the front, and are commonly called the "floating" ribs. Connected with the ribs are two kinds of muscles—the outer and the inner *intercostals*. As the lungs become inflated the outer intercostals raise the ribs upwards and outwards. As the lungs empty themselves, the inner intercostals come into play and bring the ribs back to their former position. The student's attention is drawn particularly to the movements of these muscles, as a thorough understanding of their working is essential before he can master the art of breathing. [1G]

The Pharynx. The pharynx, or throat chamber, is the cavity situated in the upper part of the throat, behind the mouth. There are five openings into it—from the ear, nose, lungs, mouth and stomach.

The throat chamber is subject to great variations, being capable of great expansion and contraction. It is the principal resonance chamber of the voice. The colour and timbre, as a matter of fact, depend almost entirely upon it. [1H]

The Nasal Cavities. The nasal cavities are really the external and internal nostrils; the last named join the pharynx. The hard and soft palates make a floor for them. The nasal cavities assist very considerably in tone production, by helping to make the voice more resonant. [2J]

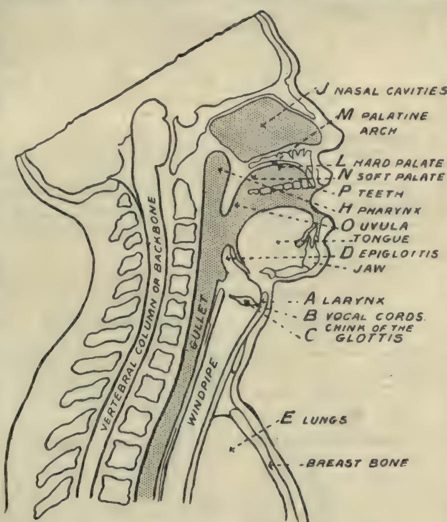
The Jaw. The lower jaw plays a very prominent part in the art of singing, helping principally in pronunciation. It is essential that it should be kept loose and free. Lamperti, in his famous "Treatise on Singing," attaches great importance to this. When the jaw is loose and free, so are the muscles of the throat. The distance between the teeth should never be less than a thumb's width when singing. [2K]

Hard Palate. If the student places his finger inside his mouth immediately behind the upper teeth, he will find a hard, fixed and slightly ribbed substance; it is known as the hard palate. On moving his finger a little further along the hard palate, he will come to a dome-like part; this is called the Palatine Arch [2M]; these two greatly influence vocal tone. [2L]

Soft Palate. Carrying the finger still further into the mouth, the student will come to a very sensitive, soft, fleshy and movable part of the roof, which possibly he may not be able to touch without feeling sick. This is called the soft palate. It consists of a number of muscles which work at will. If the student draws in a breath through the mouth as if he were going to yawn, he will feel his soft palate rise, and it will appear to become a continuation of the hard palate. He should practise raising his soft palate in this way, so that when he sings he will be able to raise or lower his palate at will. One of the most common faults of singers of the present day is their inability to do this, and in consequence they almost invariably sing with their palates "down." This makes the tone nasal and indistinct, and prevents the voice from "carrying."

These two palates may be called the sounding board of the voice, and the correct use of them is of the greatest importance. [2N]

The Uvula. At the back of the mouth, suspended from the middle of the soft palate may be seen a soft red piece of flesh about the size of the kernel of a hazel nut. This is the Uvula. It rises with the soft palate, and in some mouths seems to disappear altogether. Its work is to close the nasal passages, and so prevent the tone from becoming nasal. This does not, however, interfere at all with nasal resonance. [2O]



2. THE PHYSIOLOGY OF THE VOICE

The Teeth. No opportunity should be lost for impressing upon the student the great necessity for taking care of his teeth. Their work in singing is to help in the articulation of the consonants. A song becomes stupid and feeble when the consonants cannot be heard clearly and distinctly. The consonants, not the vowels, are the backbone of diction, and since the consonants are formed largely by the teeth, the care of the teeth is one of the first considerations in singing. [2P].

Classification of Voices. Generally speaking, human voices may be divided into two large classes, male and female. These are subdivided as follows:

MALE.

Bass. — Passo Profondo. Basso Cantante.
Baritone.
Tenor. — Tenor Robusto. Tenor Leggiero.
Alto, or Counter-tenor.

FEMALE.

Contralto.
Mezzo-soprano.
Soprano. — Soprano Drammatico. Soprano Leggiero.

The quality of the middle notes of a voice, not the compass, determines its classification.

The student cannot be too particular in grasping this fact.

During the first singing lesson it is often difficult for a teacher to classify a voice definitely. A number of lessons may be necessary before such decision can be made. For example, a student may come to him and sing a song of soprano compass with effect; but because she is able to sing the head notes in a soprano voice—even if the compass is high—it does not necessarily follow that she is a soprano. The tone and quality of her middle notes must be listened to carefully by the teacher ere he can decide.

The vocal cords of a bass and baritone are broader, thicker, and longer than those of a tenor and soprano. The *kind* of voice—soprano or contralto—is governed, therefore, chiefly by the size of the cords.

Although great similarity may exist, no two voices are quite alike; they differ in individuality as much as do faces, largely owing to the formation of the resonance chambers.

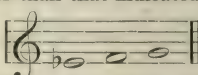
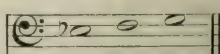
Compass. The compass of a voice is the range of sounds it is capable of producing, and these sounds are divided into registers. Each voice has three registers, which will be explained later. The table on this page shows the compass of the respective voices, but does not include voices of exceptional range.

Voice Characteristics. We must now consider the characteristics of the different voices.

BASSO PROFONDO. The Basso Profondo, which is the lowest male voice, is seldom met with nowadays. It is the fullest and deepest of all voices. Its chief characteristics are volume, intensity, richness, and broad phrasing; and its development is slow. There is always a great tendency to force, so the student must exercise much care and patience to avoid this fault, or the voice will become coarse. Another point to be carefully noted is the intonation. The vocal cords of a basso profondo are very thick, and in consequence the voice is particularly adapted to the sustained and declamatory styles of singing, but are, of course, quite unsuited for florid singing.

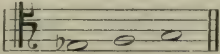
BASSO CANTANTE. Although not so heavy, the Basso Cantante is more general than the basso profondo. Besides being lighter in quality, it has greater flexibility and a little higher range, as will be seen on reference to the compass. But, compared with the tenor and women's voices, it is deep and powerful. Its notes are capable of greater resonance than those of the baritone. The lowest notes, E, F, and F♯ in an untrained basso cantante voice may be weak, but with careful training they become full and rich.

BARITONE. The Baritone in the classification of men's voices corresponds to the mezzo-soprano in women's voices, and partakes of some of the characteristics of both bass and tenor, with a greater resemblance to the former. It is capable of greater expression and modulation than the bass, besides being more flexible and mellow. It is the most general of all male voices. Although it does not possess the volume of the bass, it is fuller than the tenor. The great evil to be guarded against in the training of this voice is the tendency to shout and strain. The voice naturally is not the size of the bass, so the student must exercise great care not to force it or he will spoil the quality, and in time ruin the voice. The weakest notes of the baritone voice are the low A♭, A, and B.

TENOR. Of the male voices the Tenor is the highest. There are two kinds of tenor voices, the *Tenor Leggiero* or light tenor, and the *Tenor Robusto*, or full dramatic tenor. The volume and quality of these two varieties of tenor voices distinguish them from each other. The music for the tenor voice is usually written in the treble clef; it must be borne in mind, however, that the pitch of the notes actually sung by the tenor voice is an octave lower than that indicated. For example, the notes  when sung by a tenor are actually 

Originally, music for the tenor voice was written

in the tenor clef. The old clefs in singing are seldom used at the present. The above notes in the tenor clef would be written



Tenor Leggiero. The Tenor Leggiero, or light tenor, is noted for its brilliancy, lightness, and flexibility. The tone is most delightfully silvery, but wanting in sustaining power. It is, perhaps, the most difficult and delicate of all voices to train. It requires coaxing, then sweetness of tone and grace will result.

Tenor Robusto. The Tenor Robusto, or full dramatic tenor, like the basso profundo, is somewhat rare. It is full and rich, capable of great modulation, and can portray any passion necessary. The notes from F, first space, to B third line, are the most difficult to cultivate, and not infrequently are rather weak. Great care is necessary at the beginning of the training that the voice is not mistaken for a baritone. This is of the utmost importance, for if trained as a baritone, it will follow that the medium notes of the tenor are trained as baritone head notes, with disastrous results.

Alto. As a solo voice the Alto, or counter-tenor, is not very pleasing, but is useful as the highest voice in male part-songs and glees. It is most frequently met with in church choirs. Being an unnatural voice, very careful training is required.

Contralto. The Contralto is the fullest, deepest, and strongest of female voices, and is more capable of modulation and tender feeling than either the mezzo-soprano or soprano. Like the bass, it is not very flexible, and is particularly adapted to sustained and declamatory styles of singing. The weakest notes are from F, first space, to C, third space. Strict attention should be given to the cultivation of these notes during the first lessons, and special care must also be exercised to avoid forcing the chest notes, those from E, first line, down the scale.

With the majority of contraltos it is noticeable how weak are their medium, or middle, notes. This is due entirely to forcing the chest notes, which, when forced to any extent, become coarse and blatant, and produce, together with the weakened middle notes, the effect of two distinct voices.

The registers of contralto voices require the closest attention. Equality of tone is perhaps the most important feature to be developed in cultivating the contralto voice.

Mezzo-soprano. The Mezzo-soprano voice holds a similar position in female voices to that held by the baritone in male voices. It possesses some of the qualities of the contralto, notably fulness, mellowness, and roundness, being like the soprano inasmuch as it is capable of great flexibility. When perfect, it is often considered the most beautiful female voice; but it must be remembered that as it partakes of both contralto and soprano it must needs share the faults of both. Therefore, judgment and caution must be used in training to avoid its being taken too high or too low.

The greatest danger is that songs and exercises of too high a range are often sung by the mezzo-soprano, and if this practice is continued, the voice will be ruined. It is unadvisable, and often harmful, for a mezzo-soprano to sing contralto songs and exercises, although the result may not prove quite so disastrous as the singing of soprano songs.

At the beginning of study, let the middle notes be carefully trained, and the upper and lower notes develop naturally.

Generally, the weakest of all mezzo-soprano notes is E, fourth space

Soprano. The two kinds of soprano voices—the *Soprano Drammatico*, or dramatic soprano, and *Soprano Leggiero*, or light soprano—correspond almost exactly with the two kinds of tenor voices which have already been described. The soprano is the highest human voice. Because a woman's voice may be high in pitch, it is not necessarily a soprano—it may be a mezzo. The *quality* of the notes in every case decides the voice.

In training the soprano voice the tendency to overwork the highest notes must be strictly guarded against; if this injurious practice is continued, the tone will become weak, shrill, wiry, and thin.

The emphatic remarks made about the intelligent cultivation of the other voices previously noted apply with equal force to the light and dramatic soprano.

Respiration. It is of the utmost importance that before attempting to sing a note the student should try to acquire a correct method of respiration, or breath control.

The respiratory apparatus consists of the chest, thorax, and the respiratory tree (*arbre respiratoire*), which includes the larynx, the windpipe, the bronchi, and the lungs. The respiration of the animal kingdom is entirely opposite to that of the vegetable. In the former, oxygen is inhaled and carbonic acid exhaled; plants inhale or absorb carbonic acid and exhale oxygen.

Every human being and every animal from the moment of birth to that of death breathes; but very few of the former have naturally a correct method of respiration. It is essential that everyone, whether singers or not, should breathe in the manner intended by Nature. Unfortunately, civilisation, combined with the present mode of dress, has done much to hinder this. Savage races and the lower animals, whose bodily freedom is not impeded by clothing, breathe perfectly, because naturally.

The art of respiration comprises two movements—Inhalation or Inspiration, and Exhalation or expiration. With the former, life begins; with the latter, it ends. The average person inhales about 12 quarts of air per minute, 720 quarts per hour, 4,320 gallons per day. The lungs, however, are capable of receiving seven times this amount.

Speaking of people in general, the quantity of air they draw in at each inspiration expands the

upper part of the lungs only; when the inspiration is *full*, the lungs expand at the base also.

The student's attention should be directed to the *muscles* controlling respiration, not to the lungs, which are passive. They of themselves cannot move or extend; it is the influx of air, together with the action of the muscles, that enlarge the lung space.

Exercises on the art of inspiration will follow. After the student has thoroughly mastered the art of inhalation, he may turn his attention to that of exhalation or expiration—the outflowing of the breath; but this must not be attempted too soon. Correct exhalation is even more difficult than correct inspiration.

Beauty of tone, phrasing, expression, duration, and so on depend entirely upon a correct mode of respiration.

Breath Management. Three methods of breath management are recognised: (1) diaphragmatic, (2) intercostal, and (3) clavicular; but the first, diaphragmatic, is the only correct method.

When diaphragmatic breathing is employed the lungs, which are fully inflated, press on the diaphragm [1F], and push it down on to the stomach, which in turn expands; at the same time, the outer intercostal muscles [1G] draw the ribs upwards and outwards, and in this way the cavity of the chest is considerably enlarged. The movements of these muscles are concomitant.

If the clothing is moderately loose, the diaphragm will work naturally, enabling the student to direct his whole attention to the movements of the rib muscles.

The shoulders should on no pretext whatever be raised during the act of respiration. Both the chest and stomach must expand whilst inhaling.

The second method necessitates the movement of the ribs only, which are raised and pushed out and the stomach slightly yet unconsciously drawn in, the diaphragm remaining stationary. Although frequently employed, this method is really insufficient, and often proves injurious.

The clavicular is decidedly incorrect; any student who understands the shape of the lungs and chest will perceive how pernicious it is, and abandon it at once. When this mode of breathing is practised, the diaphragm and the lower intercostal muscles are inactive, and their work is wrongly thrown upon the shoulders and collarbone, which have to be raised and the muscles of the throat contracted to prevent the breath from rushing out from the upper parts of the lungs. The lower parts of the lungs in this method are never inflated. The column of air is shortened, and, in consequence, too great a pressure is put upon the vocal cords, setting up a hideous tremolo, which, if indulged in for any length, becomes incurable.

Some teachers of singing maintain that it is impossible for women to breathe diaphragmatically, an idea which is erroneous. It may not be possible for them to breathe so deeply as men—and owing to their structure there will always be a wider expansion of the chest—but with patient practice and perseverance every woman is able to breathe in this way.

To breathe diaphragmatically the body must be easy and natural. Both feet should be placed firmly on the ground, with one foot slightly forward bearing the full weight of the body. During practice it is advisable that the student should stand with his hands behind him, lightly resting them on the small of his back.

The shoulders must be kept back naturally and easily, and not be allowed to rise, the point of the shoulder being in a vertical line with the forward foot. When this position becomes strained the rear foot may be brought forward and the weight transferred to it. The chest must be well expanded, yet without drawing down the shoulders unnaturally. The muscles of the throat must be relaxed, the neck quite free and unconstrained, the head slightly forward and erect, not depressed, and the chin kept back, not pushed forward.

Let the mouth assume a smile so that the upper lip is slightly drawn off the teeth; also keep the tongue quite flat.

One of the commonest faults with beginners is the moving of the mouth and chin after the breath has been inhaled. This must be assiduously avoided by the student, who is recommended to practise before a mirror so as to guard against this bad habit.

Let the expression of the eyes be perfectly natural. Keep the eyebows still and the forehead smooth, as there must be no sign of effort or exertion whatsoever.

The following breathing exercises must be practised in pure air, not in a room where the air has been used up. They should never be practised when the body is fatigued, nor immediately after meals, because if the stomach is charged with food the diaphragm cannot work as it should. The best time to practise is in the morning whilst dressing, or about an hour and a half after breakfast. No tight clothing ought to be worn round neck or waist.

Although not absolutely essential, it is certainly advisable that both singers and speakers should keep their nostrils clean and free; this can be easily accomplished by using as a nose bath every morning a tumblerful of tepid water in which has been dissolved a tablespoonful of common salt. Pour a little of this into the hollow of the hand, and sniff it up the nostrils alternately three or four times. All foreign substances are removed in this way, and inhalation is greatly assisted.

Exercises for Inhalation. The first exercise is to inhale very slowly, quietly, and evenly through the mouth, which must be partly open to prevent the air passing through the nose. Place the hands lightly on each side of the body to feel the lower ribs expand. If pressed too heavily, the ribs will be prevented from moving to their fullest extent.

When the ribs are expanded to their utmost mentally count five, then let the breath rush out through the mouth. This ought to produce the sensation of the total collapse of the chest.

When five can be counted with great ease, increase the number to seven, nine, eleven, and thirteen. This exercise should be practised

twenty times a day, at four distinct intervals; it must never be practised twenty times in succession, as it is too fatiguing. It should be noted that the breath should be controlled by the diaphragm and rib muscles only.

To put it concisely, the exercise is this. Breathe slowly, quietly, and evenly through the mouth; hold the breath whilst mentally counting five; let the breath *rush* out through the mouth.

For a second exercise, inhale as in the previous exercise. Hold the breath whilst mentally counting three; re-inhale without allowing any of the first breath to escape; count one, then try and inhale again—that is, three inhalations in all—then let the breath rush out through the mouth. This must not be practised until the first exercise has been completely mastered. It must never be practised more than nine times a day at three distinct intervals. The object of this exercise is to increase the girth of the lower part of the chest.

The next exercise is to inhale through the mouth *quickly* and quietly, mentally counting five whilst holding the breath with the diaphragm and rib muscles; then let the breath *rush* out through the mouth. Gradually increase the number counted. Practise twenty times a day at four distinct intervals. It is possible that the student may make a gasping sound whilst inhaling quickly, but this can be avoided if the soft palate and uvula are raised. On no account must the shoulders be raised.

The fourth exercise is to inhale quickly and quietly. Count three, inhale; count one, inhale again; then let the breath rush out immediately through the mouth. Practise nine times a day at three distinct intervals. Should the sides of the mouth become dry, let the student inhale alternately through the nose and mouth.

Exercises for Exhalation. The first exhalation exercise is most generally used in songs, solfeggio, etc., when the breath has to be taken in hurriedly.

Inhale quickly and quietly through the mouth, hold the breath whilst mentally counting five, then let it pass out slowly and silently; keep the lower ribs expanded as long as possible, and feel that the stomach is very gradually inclining inwards and upwards. Be careful that the upper part of the chest does not move, and guard against puffing out the cheeks. Until the student becomes quite familiar with the movements required it is advisable that he should place one hand on his lower ribs and the other on his chest.

This exercise must not be attempted until the inhalation exercises have been thoroughly mastered. Practise fifteen times a day at three intervals. To express this briefly, take a *quick* quiet breath through the mouth, hold whilst mentally counting five, exhale very slowly.

A Difficult Exercise. We now come to the last exercise. It should always be used at the beginning of a song or solfeggio, or where a phrase is preceded by a rest. The remarks referring to exhalation in the first exercise apply equally to this. It requires very careful and diligent practice, or it will never be perfect.

Inhale slowly and silently through the mouth; mentally count five, and, by degrees, seven, nine, and eleven; exhale *very slowly*, keeping the ribs expanded till the last particle of air is expelled. This must not be practised more that nine times, at three distinct intervals, as it is very fatiguing.

All these exercises must be studied and persevered with in the above order to ensure complete mastery. When this has been accomplished, three of them must still be carefully and regularly practised every day, not only by the novice but also by the advanced student—inhalation, first exercise; exhalation, first exercise; exhalation, second exercise. They must be practised in this order.

Exhalation is controlled entirely by the diaphragm and rib muscles. The student must exert all his will power to prevent the rising of the former and the falling in of the latter after he has expanded the lungs by inhalation. It should be remembered that it is the will alone that can control their movements.

Another exercise of lesser importance, but beneficial to the student, is to inhale slowly, hold the breath whilst mentally counting five, then exhale slowly, counting *aloud* first as far as seven, then ten, increasing the number as he gains control over his breath. He may also recite the letters of the alphabet in the same way, but he must cease counting or reciting before the last particle of breath has expired or the end of the phrase will sound gaspy, and this will be quickly detected by a listener. It has been well said that by observing how a phrase is finished we can tell if the respiration is correct or incorrect.

Continued

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SYSTEM IN A RETAIL SHOP

Organising the Establishment. Perpetual Inventory of Stock. Executing Orders. Catalogue Systems

By D. N. DUNLOP

A RETAIL business is unavoidably burdened with an endless amount of detail, all of which must be satisfactorily dealt with from the point of view of both trader and customer. A well-considered system is needed to bring about this result, whether the business be on a large or small scale.

The system must be adapted to the needs of the army of buyers who gather in goods from all parts of the world; to the stock which must be kept up all the year round; to the goods which must be received, opened, checked, priced, sold, packed, and delivered or shipped, as the case may be. Shipping, stock, sales, order and department records must be kept. The problem presented by each phase must receive equal attention. Buying merchandise for stock requires a number of records, statistics of previous business, amount of sales, the lines most in demand, the *undesirables*, the style tendencies, the probable outlet, prices, amount on hand, lists of manufacturers, comparisons of values, prices, terms, etc. All these records must be kept available. The card system may be applied to all, and managers will find no difficulty in installing systems for dealing with these records. Ordering, selling and accounting are not the only phases of a great business which require systematising; there is the government of the vast army of employes, the care of the building and fixtures, the work-rooms in which goods are made to order, remodelled, repaired, etc. It is obvious that it would take volumes to describe systems for all of these; the most important only can be touched upon.

The Organisation of the Establishment. The general manager, who holds all the threads of government in his hands, is responsible for the organisation of the establishment and for the harmonious working of the various systems installed. One of the fundamental principles of a successful organisation, however, demands that one person alone should not be held personally responsible for all details; responsibilities are divided into sections, and every person who is capable is made responsible for a certain definite portion of the work, under the superintendence of a higher authority, and is made to feel that the firm depends upon him or her for the faithful performance of duty. Responsibility might, therefore, be divided as follows: (1) superintendent of employes; (2) superintendent of systems; (3) superintendent of buildings and fixtures; (4) supervisor of expense; (5) superintendent of counting-house; (6) superintendent of merchandise; (7) manager of publicity.

All the superintendents report to the general manager as to their own province. The superintendent of systems takes cognisance of the shipping and waggon delivery, pneumatic tube, telephone and lift services.

The superintendent of buildings has charge of supplies, stationery, printing, power, heat, lighting, machinery, water supply, ventilation, sanitation, fire-prevention, and housekeeping, each of which is placed under the authority of a responsible person.

The supervisor of expense has access to all records, investigates all items of expense in practice; sees to it that a proper balance exists between expenditure and returns; points out extravagances, suggests economies, advises as to profitable outlay on plant, equipment, etc.

The superintendent of the counting-house has jurisdiction over credits, collections, legalities, the pay roll, bookkeeping, billing, cash, auditing, etc.

The merchandise superintend nt is concerned with the buying, the travellers, the stock, the window and interior displays, warehouses, special sales, packing, etc.

The Care of the Stock. The first step in establishing the various necessary systems is to make out a classified numerical index of every article kept in stock, from a pin to a suite of furniture. The simplest method is to divide the stock into departments corresponding with the sale departments of the firm, and to designate these by means of capital letters, or combinations of letters if the departments are many. The articles sold in each department are then numbered, beginning with 1 in each case. The decimal system may here be pressed into service in large businesses with advantage, and is applied thus: We shall suppose that a haberdashery department is K; K 5 might represent pins, K 5·1 will be toilet pins, K 5·2 white safety pins, K 5·21 black steel safety pins, K 5·3 hair pins, etc.; K 6 might be cottons, K 6·1 white sewing, K 6·2 crochet, K 6·3 soft darning, etc. A card drawer or cabinet is provided for each department, and a perpetual inventory of stock kept. Every article sold, or the box, drawer or division in which it is kept, bears the distinguishing symbol, and the assistants must, in making out their bills, quote the stock number in clear figures as well as the quantity and price of each item sold. Each assistant should besides have an alphabetical and classified list of the goods in his or her charge with their symbols—with or without prices current—for consultation in case of need when making out the bills; these lists might be kept in their check books.

Perpetual Inventory of Stock. After the bills or checks for each day have been dealt with by the counting-house, they are turned over to the stockkeeper's assistants, who post up each item of sale on the proper card of the perpetual inventory, deducting the quantities sold from the stock on hand. The assistant salesmen and saleswomen have slips in all the boxes, drawers, shelves, etc., in which the goods for sale are kept, and each sale must be *at once* registered and deducted from the balance on hand. Once a week or once a month these slips are sent to the stockkeeper, new sets of slips being given out, and they are checked over with the inventory. Any article required for use in the work-room may be delivered only on written requisition, which is then clipped to the bill made out on special yellow forms, and sent to the cash desk. The assistant rings round the entry on her slip and adds the letter of the department

which has requisitioned, and the number of the requisition order in the proper columns provided for the purpose on the slip.

It is important that the danger limit of every article of stock be clearly stated at the top of its inventory card in red ink. The clerk who posts up the sales must carefully watch this number, and when his balance approaches this limit, he clips on to the card a red tab; the stockkeeper begins his day's work by picking out all the cards so tabbed and sending a requisition notification to the buyer concerned. An alphabetical key-index will be required in connection with the perpetual inventory if this be indexed numerically.

It is obvious that the proper care, management, and accounting for stock forms the most important component of a comprehensive system for a retail house. On the intelligent and practical provision and accounting of stock depends the vital question of turnover and of returns for invested capital. The first essential is that each buyer should have means of knowing at all times the state of his stock, which lines of goods are popular and sell off rapidly, which are likely to remain on hand, what quantity of stock is usually required to meet the needs of various seasons of the year. The supply ordered may therefore be kept close to the probable requirements for the period following, and the necessity of marking down goods as bargains in order to force a sale of unsaleable goods is, to a great extent, obviated.

With the system here outlined, such data are always at the buyers' service, and from the perpetual inventory cards a number of useful statements can be computed as desired.

Not only does stock kept in such a manner ensure an accurate record of every article, and what profit every item in such department is paying, but it also forms a check on stock, and detects thefts, losses and waste. It is obviously a great improvement on the old method of stocktaking once a year, by means of a stockman.

Systems for Handling Orders and Purchases. Next in importance come the orders and purchases which are intimately connected with the system of accounting; in fact, they form a link between it and the department of merchandise. The basis of this system is manifolding, not only as a time and labour saver, but in order to secure greater accuracy. The manifolding is done by means of the billing machine, a typewriter which produces as many as thirteen legible copies at one writing. When orders come in from country customers, they are first stamped by means of a rubber stamp with the following particulars: the order register number, the customer's correspondence number, date, account number, carriage or freight, credit, departments. The *Order Register* is a valuable adjunct to this method of handling orders. All orders are registered at once on receipt, and numbered consecutively in the register, so that each number must be accounted for, and no orders go astray without being detected. This number accompanies every item in the order on its progress to the packing and shipping room. The correspondence number is found in the marking or correspondence department from the customers' card index, which also furnishes the folio number; it acts as registration mark for the correspondence file, indicating the folder in which it will be filed as soon as the order has been filled. Before the order passes on to the order department, the customer's ledger or account number is filled in—this is perpetual. Opposite *credit* is the signature or initials of the credit manager authorising the credit. Copies are then made out in the order department where the orders are sorted into two groups: (1) for execution the same day; (2) for orders of which some part must be ordered or procured.

Manifolding System. Manifold copies are then made, as the order is copied from the original, on forms all plainly headed and lettered as follows:

A, the customer's invoice.

B, duplicate invoice for the file.

C, the shipping and charge sheet, on which the warehouseman fills in the number and weight of packages, checked by the packer, whose signature forms a receipt for the assembled goods on the order; the railway or carriage charges are added after consignment.

D, consignment note for the carriers.

E, stock clerk's copy.

F, billing copy.

G, etc., in duplicate, for every department concerned in filling the order. By using the billing machine it is easy to split an order so that only the portion of the order to be filled by any one department need appear on that department's copy. One of these copies is kept on file in the department, while the other is sent with the goods to the packing room, and signed as a receipt by the packer after checking the goods over.

A posting slip can also be supplied, containing only the date, name and address, total amount. This posted slip of completed orders enables the accounting department to post the charge at once to the proper account in the ledger. The billing copy serves with the day's sales sheet to form a loose-leaf sales or day book.

By manifolding the order thus every department of the firm concerned can set to work simultaneously without waiting for one another.

In order to expedite the work still further the whole corps of typists in establishments having an extensive mail order business is set to write the orders during the morning, when there is a rush of orders, so that all orders for goods in stock can be sent off the same day. After the dinner hour, probably, only two or three typists will be required for orders, while the rest mail invoices, do the correspondence, address circulars, etc., unless this be done outside by contract.

Incomplete Orders. With regard to the second group of orders, a definite system is required to prevent any of the orders getting shelved or forgotten, should delay occur in procuring the missing items of the order. As soon as a department notifies that an item cannot be supplied—which should be done by means of a written notification to the order department—an acknowledgment is at once sent to the customer with an explanation of the cause of the delay, and an intimation of the probable date on which the full order can be despatched, thus giving the customer the option of having all the available goods forwarded without waiting for the article which remains to be procured.

In the meantime, the original order, the duplicate forms, and a duplicate of requisition cards sent to buyers for the goods required to complete the order, are clipped together and filed in the Incomplete Order File, indexed numerically by the Order Register Number. This file is looked through daily by the order clerk so that the orders may be filled as soon as the goods arrive.

In the Receiving Room. When the purchasing department has, on requisition from a buyer, issued a purchase order, a duplicate is at once sent to the receiving clerk, accompanied by a

coloured slip containing instructions as to the disposal of the goods on arrival. When the purchase order is sent out to fill an uncompleted order, the instruction slip is marked *Urgent. Notifying Order Department. Order Register No.*——, and a department copy of the original order is clipped to the purchase order. On arrival of the goods, the receiving clerk sends the instruction slip by pneumatic tube to the order department, and the goods, on being checked, to the department concerned, with the two other forms still attached.

The department goods clerk signs the purchase order duplicate as a receipt, and returns it to the receiving clerk. The order is then treated like the new orders, and the goods are assembled from the departments concerned.

Many orders received are simple, and concern but one department, and are sent off by post; the routine in this case is obvious and needs no further explanation.

How to Handle Catalogues. A retail house is concerned with the handling of two classes of catalogues:

(1). Their own, dealt with by their publicity department.

(2). Those of manufacturers and wholesale merchants from whom they purchase, and kept in the merchandise department for the benefit of the buyers.

The first class, if judiciously despatched from carefully compiled mailing lists, should yield good results, which, by means of a simple system, may be traced and checked.

The practice of distributing catalogues broadcast all over the country, using unchecked mailing lists for the purpose, is a very wasteful one. The preparation and distribution of catalogues is the work of the publicity department, and should on no account be entrusted to an agency. On installing the system, a list of from 4,000 to 6,000 names should be made out on cards, ruled to show name and address of prospective customer, date, class of catalogue, orders, amounts, departments, remarks. The list should include all customers of the firm, not only those who have accounts but the cash customers at whose houses the vans deliver purchases.

The cards are filed alphabetically, or in some cases by names of towns with alphabetical guide cards, according to the nature of the business done. When a new catalogue is ready to be mailed, one of the catalogue clerks looks through the Order Register and checks it with the catalogue mailing card index, ascertaining which names in the latter have sent orders since the last catalogue was sent out, and noting the date, amount of purchase, and departments concerned, the latter as a guide in despatching especial literature, notices of sales, etc. The goods in the catalogues are all classified as explained above, bearing department letter and numbers. If the customer be requested to quote this designation in ordering, and a column in the Order Register be headed Catalogue No., for information as to whether the numbers were given in the order or not (a check mark for affirmative, a cross for negative) the catalogue clerk would know whether the orders were due to catalogues. On seeing a cross, he would note whether the name was included in his index; if not, a card would at once be made up, and added to his mailing list. The returns from the orders thus traced to catalogues are credited in the ledger to Catalogues or Publicity as against the expenditure debited for the make-up, and the balance would show up in the profit and loss account.

When catalogues are returned because the addressee has removed, his card is removed from the cabinet. Thus the expense of sending out unremunerative catalogues indefinitely to those who are not interested would be avoided. Before giving up an apparently uninterested customer, care should be taken to ascertain whether he has received publicity literature of all kinds from the firm, and that none of them have brought returns.

Incoming Catalogues. The handling of the second class of catalogues includes filing and cross indexing for the purpose of rendering the information contained therein instantly available, and the making of quotation lists for the buyers. Catalogues and price books, etc., are, on arrival, stamped prominently on the cover with the date. Books are filed on shelves or in drawers with the backs uppermost exposed to view, each bearing a number on a small adhesive label. This number should, if possible, be the same as the correspondence and folio number of the firms in question, as this tends to simplify the records; with a system of interhouse telephones or speaking tubes, this is easily managed. The leaflets, circulars, newspaper cuttings, or typewritten quotations extracted from correspondence, are filed vertically in folders like the correspondence. [See Business Management.] A cross index is then made out according to articles or classes of articles, such as haberdashery, tinware, silks, calicoes, pins, sewing cotton, etc. The cards bear the subject prominently written as a heading, while the space below is subdivided into columns for name of firm, address, catalogue number, folder number, date, and page in catalogue.

The Quotation of Price Index. The quotation index is next made out, a card being allotted to each article kept in stock. An inch of this card is ruled off horizontally across the top of the card, in the left-hand corner the name of the article; about two-thirds of the width of the card is divided into narrow columns, each allotted to one of the firms who supply the article, the catalogue number also given; the horizontal rulings are for date of quotation, the terms of payment, cash discount, freight rate. The rest of the card is devoted to the various sizes or types of the article. Both sides of the card can be used. This furnishes a complete comparison of quotations of cost prices with terms of payment. If desirable the last column may contain the selling price. In cases where the prices fluctuate considerably new cards will have to be made out which are filed in front of the old ones, kept in the index for reference. In order to distinguish the latest quotation card, it is a good plan to make a mark in red ink on the top edge of the card; this can be easily scraped off with a knife when the card is superseded.

Occasionally alterations can be made by using a little gummed paper to cover the discarded price.

This price card index forms a valuable buyer's guide for purchasing goods at the lowest prices. There is no article that cannot be classified and subdivided in the heading to furnish competitive prices. Finally, this system, although designed for a large mixed retail house, adapts itself in simplified form to much smaller concerns.

Continued

THE PRINCIPLES OF BREWING

The Essential Processes. Types of Breweries. The Brewer's Plant. The Influence of Natural Waters upon the Character of Beer

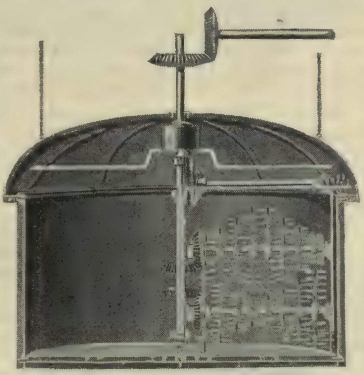
TO give an account of the development of the art of brewing in its entirety would be to reprint a large section of the general history of the world, for from the very earliest times man has made a practice of preparing intoxicating liquors from decoctions by the simple process of fermentation. This may be historically interesting, but it would be of little practical value, and the main object of this article is to assist the beginner who desires to learn how to brew and how to become a brewer.

General Outline. In order that the prospective brewer may be able to understand the detailed descriptions of the processes which follow, we will first of all give a brief outline of the simplest form of brewing. We will defer description of the materials, premising that every reader is aware that beer is brewed from water, malt and hops, which are fermented by means of the yeast plant.

The malt is ground in a mill till every corn is at least cracked, and is then known as *grist*. This grist is run into a vessel known as the mash-tun, and mixed with a quantity of hot water—water in brewers' parlance being always referred to as *liquor*. Once mixed with liquor, the grist again changes its name, and is called *goods*.

After standing a certain time at a fixed temperature, the liquor is drawn off from the goods, and becomes the *first wort*. As the whole of the properties have not yet been extracted from the goods, more hot liquor is sprinkled over the mass at the bottom of the mash-tun by means of a mechanical sprinkler. This serves to wash out any wort that may be held back by the goods, and also completes the extraction of the soluble portions of the malt. The process of washing is referred to as *sparging*.

The next step is to boil the worts, and this is done in the copper, either by steam heat or by means of furnaces. While in the copper the worts receive the addition of the hops; but the exact point at which the hops are added depends upon the sort of beer being brewed, and on the custom of the brewery, as will be explained. Wort and hops now pass into a large vessel called the *hop back*, and as soon as the hops have settled the wort is run off from them and is cooled in large, shallow, rectangular tanks called coolers, and later by passing over a horizontal or vertical refrigerator.



1. MASH-TUN, SHOWING RAKES AND SPARGER (Lumley & Co., Ltd.)

The wort once cooled, it is run into the fermenting vessels, which are called *rounds*, *squares*, *tuns*, or *vats*, according to their shapes. The liquid enters the vessel as wort, but leaves it as beer, because at this stage fermentation is induced by the addition of yeast, and part of the sugars in the wort are converted into carbonic acid and alcohol.

Fermentation takes some time, the activity of the yeast, and the strength of the beer brewed, being important factors. When the brewer finds that fermentation has progressed far enough, he draws off his beer into casks, or into a large vessel called a *racking square*, from which the beverage is drawn off to the casks.

There are two main types of brewery at present constructed, though older buildings will present almost innumerable combinations of the two systems—namely, the *tower* and the *horizontal* plants.

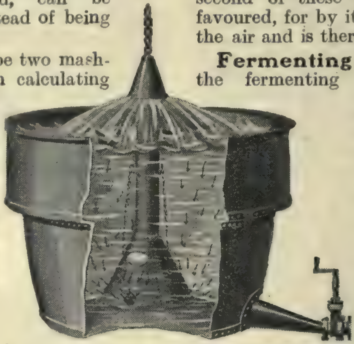
Tower and Horizontal Breweries. In a perfect tower brewery, the liquor is pumped straight from the well or spring to large vessels at the very top of the building; these vessels are called the *cold-liquor back*, holding cold water, and the *hot-liquor back*, containing hot water. No more pumping is necessary, the various vessels, backs, coppers, and so forth being placed on floors directly underneath one another in the exact order in which they are used, so that at the top of the building you have pure water, and in the cellars you have beer. Starting at the top and walking down, you can see every stage of the process. This sounds very convenient, but, as a matter of fact, it is not in favour with brewers. In the first place, the head brewer's attention is required in several departments at once, and the innumerable flights of stairs exhaust him and greatly hinder his powers of supervision. Moreover, if the business of the brewery increases, and extensions are necessary, a tower cannot be increased, and a second brewery has to be built. Added to this, towers are costly to erect and maintain.

Horizontal breweries consist of one or more long buildings of two or more stories, placed side by side. The pump requirements are increased, for the water has to be pumped to the hot and cold liquor backs, and again the wort has to be pumped twice, first from the under back, or vessel below the mash-tun, to the coppers, and later from the hop-back to the cooling plant. But the advantages of this mode of construction are great. The brewer has his mash-tuns, his coppers, and his fermenting rounds all closer together, and he has only a short distance to go between each. He is less fatigued, and can supervise better. Should extensions be required at any time they can be made easily.

Tanks, Backs and Mash-tuns. Brewers differ in their opinions as to the best materials of which these important vessels should be constructed. Some favour wood, either oak or one of the many pines, while others believe that cast iron, or even copper is preferable. Of whatever material they are made they must be kept scrupulously clean.

and frequently scoured and disinfected. The cold-liquor back is connected with the pump. The hot-liquor back receives its hot water from the coppers, or from a detached boiler, or from the cold spring, the water being subsequently heated by means of steam driven through it, or by heated steam pipes within it, or by steam driven into a jacket surrounding the vessel. The last two methods are the most satisfactory and economical, for the exhaust steam from the brewery engine, though soiled, can be utilised to heat the liquor instead of being wasted.

It is better that there should be two mash-tuns, differing in capacity. In calculating capacity of the mash-tuns it is well to allow at least three and a half barrels capacity for each quarter of malt that the tun is to receive. The tuns themselves are made of wood, wood lined with copper, or of iron. The tuns should have false bottoms, to permit of the wort being drawn off from below, and these bottoms must be securely fastened or they may shift and disturb the mashing. They must be well perforated. Most breweries are now equipped with mashing rakes, which revolve by machinery inside the tuns, and enable the brewer to mix his mash thoroughly; and we shall assume that they are to be used.



2. BREWING COPPER WITH FOUNTAIN
(Lumley & Co., Ltd.)

Above the mash-tun, or placed so as to be able to be brought into convenient action, are revolving perforated sprinklers, much like our familiar lawn sprinklers. These are the *spargers*, and it is of the greatest importance for the brewer to see that the sparger delivers an equal volume of water over the whole of the mash-tun when it is working [1].

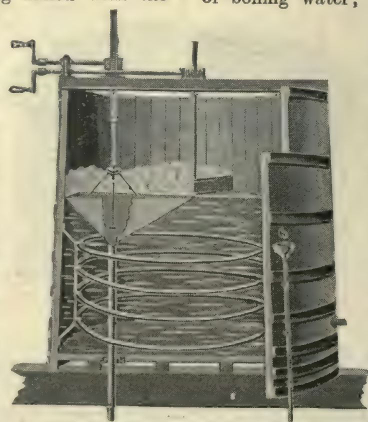
Grist Mill. Before being mixed with the liquor the malt must be ground, and a number of mills for this purpose have been invented. The main point to be aimed at is that the malt, which has previously been screened to free it from dirt and rootlets, shall be sufficiently crushed to enable the liquor to get at the contents, but shall not be ground so fine as to form a porridge with the mashing liquor. Very often, in modern breweries, the student will find mashing machines which mix the water with the grist as both pass into the mash-tun. These are convenient and economical.

Coppers and Coolers. It is usual to collect the wort in an underback beneath the mash-tun prior to transferring it to the coppers. The boiling coppers may be heated directly by fire or by means of a steam jacket. Their size depends on the custom of the brewery, some brewers preferring to boil the whole of the wort of one brewing at once, while others make two or even three boilings of the wort from the mash-tun. To prevent the wort from boiling over, many brewers have a conical lid with a hole in the centre, called a dome, let down some distance into the copper. The boiling wort bubbles up through the hole in the lid, and so returns to the copper without boiling over. There are other forms of this device, called *fountains*, upon the market [2].

Coolers are large flat trays into which the hot wort from the hop back is run. Refrigerators consist of a set of pipes placed horizontally or vertically, through which cold water runs, and over the outside of which the wort slowly travels. The second of these patterns [4] is one very much favoured, for by its use the wort is well exposed to the air and is therefore well aerated.

Fermenting Vessels. Strictly speaking, the fermenting vessel is the next piece of plant, but for Excise purposes, as will be explained later, very many brewers run their wort from the coolers to a special collecting vessel, where it remains for twelve hours or until the Revenue officers have satisfied themselves as to its strength. Then it goes into the fermenting vessels. Collecting vessels, like fermenting tuns, may be either round or square, and are made in the same way; but they may be of any convenient depth, and may be filled close up to the top. Fermenting vessels are made of wood, slate, or stone. Of wooden vessels, those made of English oak are the most durable and the best, but they are very costly, and, therefore, many brewers make their tuns of Norwegian and Dantzig firs. The manufacture of these vats forms an important branch of the cooper's trade, and need not be dealt with here.

All fermenting vessels must be scoured and sterilised before the wort is run into them. With wooden tuns, this can be effected by means of boiling water; but if the vessels are of slate, very hot water cannot be used, as slate splits at the temperature of 212° F. Slate tuns are therefore cleansed with neutral sulphite of lime. Of course, stone and slate vessels are made square. Fermenting tuns should be provided with coils of pipes in a conical form, rising from the bottom through which hot or cold water may be run. These are called *attemperators*, and their use is to enable the brewer to maintain any desired temperature within the fermenting wort. Tuns are generally provided with some form of mechanical skimming board, which enables the rising head to be quickly skimmed off and collected [3].



3. FERMENTING TUN WITH SKIMMER AND ATTEMPERATOR
(Lumley & Co., Ltd.)

Often it is necessary to agitate slightly beer which is fermenting—to "rouse" it is the technical term—and appliances for doing this are to be found in many breweries. One very effective method is by means of sinking and pulling up a small weighted barrel, with holes bored in it. This is very simple, and rouses the beer well, while at the same time it increases the aeration of the liquor. Again, a centrifugal pump which can

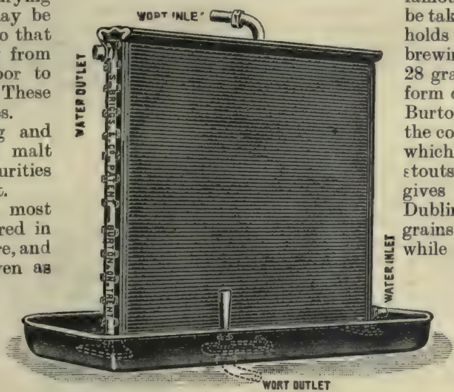
deliver a stream of the beer from the bottom of the tun to a few inches above the surface of the fermenting wort is also a capital rouser and aerator, but it is costly.

Cleaning and Malting Plants. Every barrel that has been used must be thoroughly cleansed before it is filled again, and for this purpose a large number of patent machines have been devised. The general principle of most of them, however, is the forcing of steam at high pressure, and therefore superheated, into the vessel. Our readers are familiar with the bottle-washing appliances which are to be seen all over the country in many kinds of factories. A boiler, supplying a plentiful amount of boiling water, with mains and so forth, for conducting the water to the various parts of the brewery, complete the cleaning plant.

Where the brewer makes his own malt, he must have a number of apartments, with cemented or tiled floors, on which to prepare it. He must also have a cistern and sprinklers, for steeping and sprinkling the grain. A drying kiln is necessary, and it may be arranged with two floors so that the malt may run easily from the upper, or cooler, floor to the lower or hotter one. These kilns are heated by furnaces.

Machinery for screening and cleansing the barley and malt from dust and other impurities is also included in the plant.

Hop Storage. In most breweries the hops are stored in a cool loft, free from moisture, and with a temperature as even as possible. But the most modern establishments have introduced a system of cold storage, which is very economical in the long run. A number of refrigerating chambers, similar to those utilised for keeping meat on large steamers, are set aside for the storage of hops. These rooms are kept at a very low temperature by means of carbonic acid refrigerators, and it is claimed that hops may be stored thus for any number of years without undergoing any deterioration. This is important, for in a good year the brewer can buy in a large store, and so be independent of the rise in the market if, in the following year, the crop should fail, and prices be exorbitantly high.



4. A MODERN VERTICAL REFRIGERATOR

Brewing Waters. All the natural waters contain a certain percentage of salts, and the proportion of these, one to another, determines the fitness or unsuitability of the liquor for brewing. Again, the proportions of salts give to the beer brewed from the water its distinctive character. Beers brewed at Burton-on-Trent differ materially from those brewed at Romford or London, though the process of brewing may be identical in the breweries. This is because the Burton water is peculiarly good for brewers' use.

As a guide, we give the analysis of the two principal waters used in the brewing metropolis. The quantities of salts contained are stated in grains per gallon.

Carbonates of lime and magnesia ..	11·4
Sulphate of lime	43·0
Sulphate of magnesia	12·9
Chlorides of the alkalies	5·0

This is the composition of the gravel water of the town. From deep wells the Burton brewer obtains water containing, in grains per gallon, the following salts:

Carbonates of lime and magnesia ..	15·4
Sulphate of lime	61·9
Sulphate of magnesia	30·6
Alkaline chlorides	4·2

Compare these analyses with that of water used in one of the Thames Valley breweries which contains, in grains per gallon, according to analysis, the following salts:

Carbonates of lime and magnesia ..	4·9
Alkaline carbonates	13·0
Alkaline sulphates	14·4
Alkaline chlorides	13·9

The difference in composition is plain. These analyses were made by Mr. E. R. Southby, the famous brewing expert, and may be taken as typical. This authority holds that water for first-class brewing should contain from 18 to 28 grains of sulphuric acid, in the form of sulphates, per gallon, for Burton beers. For black beers the composition of the water from which the celebrated Dublin stouts and porters are brewed gives the best results. The Dublin water contains only 0·8 grains per gallon of sulphates, while of the carbonates of lime and magnesia 11 grains per gallon is about the average. The chlorides are very small in amount, 1·8 grains per gallon being about the average.

Brewing analysts believe that the carbonates of the heavy earths such as lime and magnesia should be present in brewing waters to the extent of about ten grains per gallon, and there must always be a certain proportion of chlorides. If the water be deficient in chlorides they must be added to the liquor by the brewer. For pale ales the sulphates of lime and magnesia are essential to success, and the brewer should add to his liquor sufficient of these sulphates to bring the water up to the Burton standard. The sulphates and carbonates of the true alkalies, on the other hand, are injurious, as are all combinations of iron, and where the latter are present the iron will have to be removed before the water is fit for brewing.

Nitrates and nitrites of alkalies and minerals in the water have a restraining power on the yeast, and fermentation is slow and irregular. The yeast rapidly deteriorates, loses its character, and the beers are poor and unpalatable. There is no really reliable method of getting rid of the nitrates, and the only thing the brewer can do is to make frequent changes in his yeast, obtaining the plant from breweries where the water is not loaded with nitrates. Purely organic matter in the water must be removed by filtration, or the beer will rapidly spoil and the brewery will suffer accordingly. The brewer will have to rely on a chemist for estimation of the organic matter in the water, and this matter is generally stated in terms of *albuminoid ammonia.* A good water should have less than 0·05 parts per million of albuminoid ammonia.

Continued

continued from page 5933

ROTARY AND OTHER PUMPS

Rotary, Drum, Centrifugal, Worthington, and Ashley Pumps. Pumping Machinery and Pump Speeds

By Professor HENRY ROBINSON

FOR hard usage in shallow depths, up to 30 ft., rotary pumps are very efficient both with clean and with dirty water. The wheels should be of cast steel carefully turned, chased, and well fitted into the pump chest to ensure silence in working as well as efficiency.

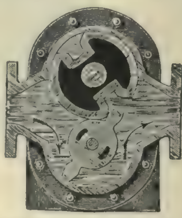
The Drum Pump. This pump [10] is suitable for removing semi-liquids, such as slurry, or wastes from breweries, paper mills, soap manufactories, etc. It consists of a revolving piston sweeping out the cylinder at every revolution, the revolving piston dipping into a revolving valve or cylindrical drum, the openings in which are arranged so that the piston passes through without slip, back pressure, or undue friction. When the revolving piston moves round from the revolving valve a vacuum is formed, into which the water flows and is forced in the front face of the piston.

Water-seal Rotary Pump. Another form of rotary pump is shown in 11, and is manufactured by the Albany Engineering Company. The chief feature of this pump is that slip and leakage have been reduced by the introduction of groove cuts along the face and edges of the teeth, so that in rotating a body of water lodges in the grooves, forming a water-seal joint, or cushion, between the casing and the rotating rollers, thereby producing an efficient vacuum. Centrifugal force also adds to the efficiency of the pump.

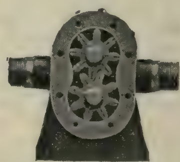
Centrifugal Pumps. When large volumes of water have to be raised small heights, centrifugal pumps are very suitable. The general construction of this form of pump consists of a revolving shaft furnished with vanes extending from near the centre outwards to the circumference of the impeller, and are usually curved backwards. The impeller is encased in an approximately circular box. The centrifugal force imparted to the water by the revolving vanes tends to move outward, and is allowed to pass off, through the delivery outlet of the case, tangentially to the impeller.

Preparatory to starting a centrifugal pump it is necessary to charge it with the liquid that is to be pumped. This can be done either by an overhead tank, steam ejector, or, if it be pumping water, by a branch of the water main. It is advisable to place a foot valve on the end of the suction pipe to hold up the water, as pumps of this description are liable to drop the load apparently without any sufficient cause. It is also advisable to keep the pump as near the water-level as possible. To meet the difficulties that arise where centrifugal pumps have to be used for high lifts, and where the space for them is limited, compound pumps have been successfully employed. The size of the wheels and the speed of these pumps is lessened. Centrifugal pumps work with their greatest efficiency only when a constant head is maintained. The efficiency has been found to be 50 per cent. for small and 70 per cent. for large centrifugal pumps. The speed of centrifugal pumps is dealt with four pages further on.

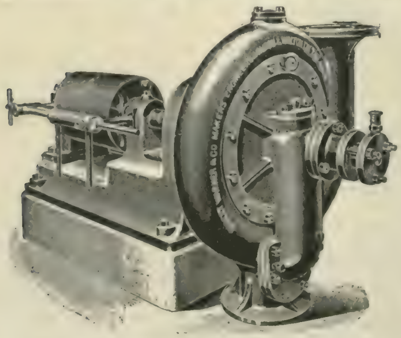
The illustration [12] shows one of Messrs. Robert Warner & Co.'s 7-in. belt-driven centrifugal pumps with fast and loose pulleys. This pump is capable of delivering 750 gallons per minute for a lift of 20 ft. when working at 560 revolutions per minute. The diameter of the propeller is 1 ft. 5 in.



10. SECTION OF DRUM PUMP



11. WATER-SEAL ROTARY PUMP



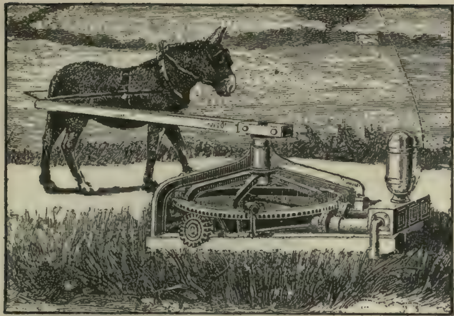
12. BELT-DRIVEN CENTRIFUGAL PUMP

The salvage of ships with their cargoes has for many years been a subject of considerable interest, not only to underwriters and shipowners, but to everyone who has any concern in maritime affairs; and this is not at all surprising if the statement (which is made upon good authority) is true that the annual loss of ships and cargoes on the coast of Great Britain exceeds £9,000,000.

The employment of direct-acting centrifugal pumping engines to salvage ships has engaged the attention of Messrs. J. & H. Gwynne for many years, and their "Invincible" plant has been largely used. An interesting example of the use of these pumps for salvage is shown in 15.

The Ariadne was sunk off the pier at Barrow, and the illustration shows the vessel at low water with the "Invincible" centrifugal pumping engines belonging to the British Marine Salvage Company, Limited, in position. The decks being submerged at low water, the hatch combings had to be built upon, and the operations were rendered still more difficult owing to the rapidity of the rise of the tide. The work was successfully carried out, and the vessel placed in dry dock for repair.

The "Invincible" pumping engines and pumps [16] will, it is maintained, aspirate or draw water

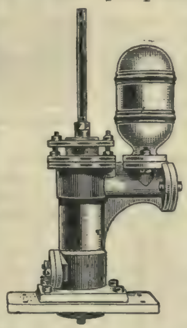


13. PUMPING BY ANIMAL POWER

28 ft., and the larger sizes 25 ft. to 30 ft.; but when a steam ejector is used for charging, the top of the pump casing should be within 25 ft. of the water level, as that is the extent to which such an appliance is efficient; but when the pump is once charged it will fetch the water 30 ft., provided always that the joints, etc., are perfectly tight.

Pumping by Animal and Windmill Power. Animal power is often employed to drive small pumps. Figure 13 shows this manner of working pumps. The animal is harnessed to a pole and walks round and round, operating gear wheels which drive the pump. This particular illustration shows one of Messrs. Merryweather & Sons' appliances.

The employment of windmills for driving pumps has been successful in many places, but as the results are dependent on the wind, tanks should be provided to store the water and to ensure a fairly constant supply. Figure 19 shows a typical windmill pumping station for small supplies. Figure 14 shows the kind of pump worked by windmills.



14. WINDMILL PUMP

Strength of Pumping Machinery. The strength of the pumps and machinery must be in proportion to the head of water against which they have to pump. The pressure per unit of area is independent of the area of the pipe, but additional work is thrown on the pumps if the pipes are too small, or if they have sharp bends, owing to the friction caused thereby. Let D = diameter of pump in inches, S = stroke in inches, N = strokes per hour, then $D^2 \times S \times N \times {\cdot}00284$ = contents of pump in gallons per hour. Thus, a pump 2 in. bore × 9 in. stroke, making 1,500 complete strokes per hour, would deliver 151 gallons per hour, if there was no waste; but a percentage of water always slips by the valves at the end of each half-stroke, and it is usual to allow about 25 per cent. for this loss.

To obtain a continuous and even delivery of water, and to reduce the shock on the valves at the reversal of the stroke, pumps have been constructed with two and three plungers discharging into a common rising main. The plungers work in rotation, being operated by cranks on the same shaft. The illustration [20] shows a three-throw pump manufactured by Messrs. Hayward-Tyler & Co. In this case the pump is operated by an electrical motor of 15-horse power. The plungers of the pump are 5 in. in diameter, with a 9-in. stroke, the revolutions being 46·5 per minute. This pump is capable of discharging 50,000 lb. of water per hour against a pressure of 160 lb. per square inch.

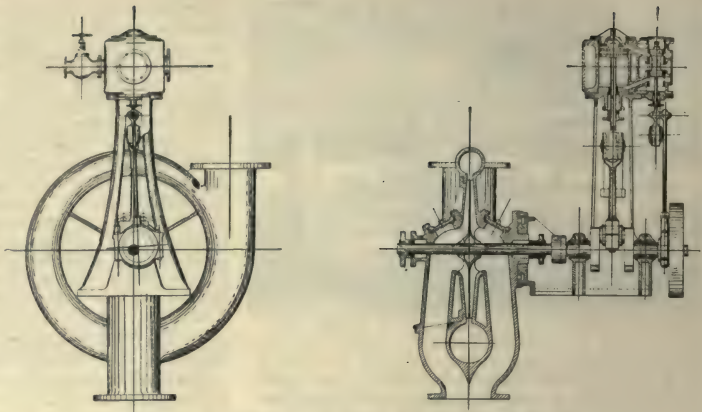
In the crank and flywheel type the pump-piston speed is variable, according to the angularity of the connecting-rod, and the quantity of water varies from zero at the ends of the stroke to a maximum about half stroke, when the pistons are moving with a velocity equal to that of the cranks. This, it will be noted, causes a variation in the rate of delivery of the water in the rising main. The severe pressures that would be set up in the pump (due to the inertia of the water, and its velocity) may be compensated for by placing on the rising main at the pump an air vessel, which acts as a buffer, or cushion of air, and takes up the shock. Figure 17 shows a form of air vessel that has been employed by the writer on several of the works that he has carried out. In cases where heavy pressures arise, a difficulty exists in retaining the air in the vessel. It is therefore necessary to provide an air pump to supply the vessel with air as required.

The Worthington Pump. This form of pump meets the conditions as regards varying pressures that have been referred to, the delivery being uniform at all parts of the stroke. There are two pumps, each double acting, the flow from one dovetailing into the flow from the other. The steam cylinders, as will be seen from 18, are directly in line with the pumps, there being no cranks or flywheels. This illustration shows an 800-horse power Worthington pumping engine. The low-pressure cylinders are 82 in. and the high-pressure 41 in. in diameter, the pump plungers being 12 in. in diameter. The steam pressure is 100 lb. per square inch. This engine works against a pressure of 1,500 lb. per square inch, which is equivalent to a dead load of 151 tons.

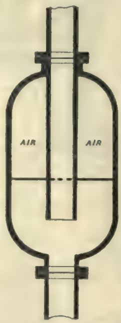
The more recent form of this pump [21] has been installed at the East London Waterworks, and was constructed by Messrs.

15. "INVINCIBLE" PUMPING PLANT AT SALVAGE WORK

James Simpson & Co. The duplex pumping engine invented by the late Mr. Henry R. Worthington possessed reliability and simplicity, but was not economical in steam consumption. To accomplish this by a flywheel, or similar device for storing energy, would have taken away the characteristic advantages from the engine, so the Worthington compensating system was adopted, which permits the cutting-off of the steam in the cylinders, and its subsequent expansion to any degree or extent, thus giving to the direct-acting engine the advantages, as regards economy due to expansion, that are obtained by the flywheel engine, without in any way affecting the duplex principle. Figure 21 shows the engine constructed with this compensating arrangement. The attachment consists generally of two oscillating cylinders, supported from the main frames. These cylinders contain plungers, which are attached to the piston rods between the steam and the water ends. They are connected by pipes, and are filled with water or other fluid, to the surface of which air is admitted at a pressure suitable to the duty to be accomplished, for the purpose of maintaining a constant load at a practically constant pressure on their pistons through the medium of the liquid. The action of the plungers is to resist the advance at the beginning of the stroke, and to assist it at the end, the air meanwhile exerting its unvarying influence at each end of the stroke. The two cylinders act in concert, being placed directly opposite each other, and perform the function of a flywheel. In the arrangement of piston rods the high-pressure ones are directly coupled to the pump rods. Between the high-pressure cylinders and the pump end there is a crosshead to which are attached two side rods connecting to the low-pressure pistons. The piston rods between the intermediate and low-pressure cylinders work through long sleeves, thus doing away with two stuffing boxes.



16. "INVINCIBLE" PUMPING ENGINE AND PUMP



17. AIR VESSEL

Bore-hole Pumps. Where water is to be raised from bore-holes, a pump specially made for the purpose is employed. Figure 22 shows one of Robert Warner & Co.'s bore-hole pumps. The size and length of stroke varies from 3 in. upwards, according to the diameter of the bore-hole and the discharge required.

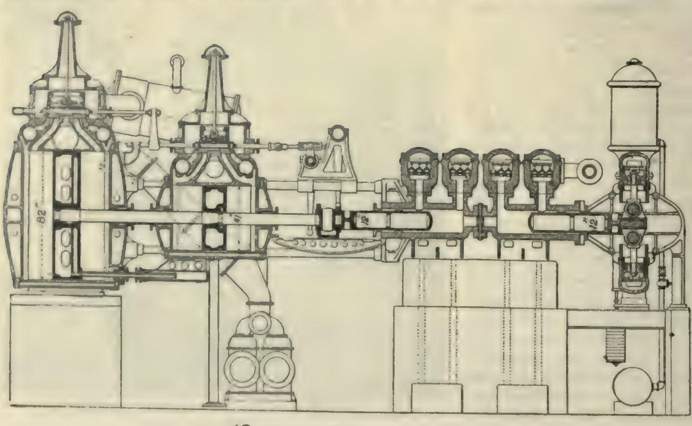
With this pump the usual suction valve is dispensed with, and in lieu of it a delivery valve is placed above the bucket. On the up stroke of the latter the water flows into the barrel; on the down stroke the water passes through the bucket valve as the latter descends, while on the up stroke it is lifted and forced through the delivery valve.

The suction is fitted directly to the bottom of the barrel, so that the water flows straight up into it.

The bucket and delivery valve both come out and go down at the same time, and there is no separate operation required for withdrawing the foot valve, as is the case with ordinary pumps.

It is sometimes necessary to place a strainer on the suction pipe to prevent solid or gritty matter gaining access to the pump. Figure 23 shows Messrs. Hayward-Tyler & Co.'s foot valve and strainer for bore-hole pumps, while 24 depicts Messrs. Ham Baker's strainer for ordinary suction pipes.

The Ashley Pump. This pump was designed to supersede the old form of bucket and bottom valve pump, and to remove, in so doing, two of the difficulties experienced in connection with



18. WORTHINGTON PUMP

19. WINDMILL FOR PUMP-DRIVING

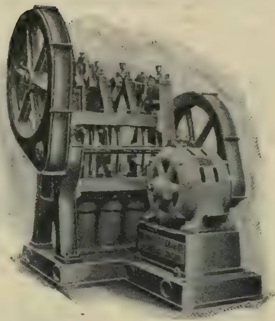
underground pumping. It is sometimes the case in this class of pumping, notably in wells, that the pump itself has to be placed at a great depth below the surface of the ground and connected to the engine driving it by a corresponding length of pump rod.

In some cases, when a stoppage occurs, the water may rise in the pumping shaft to a considerable height (sometimes 200 ft. or 300 ft.) above the level at which the pump is fixed, and render it impossible, without the aid of divers, of approach from the outside for examination or repair. These conditions necessitate the use of a pump constructed so that all its working parts can be drawn up through the rising main when it is desired to effect any such examination or repair, and the diameter of the bucket must therefore be a little less than the diameter of the rising main through which it has to be drawn to the surface of the ground.

The type of pump mostly used hitherto in well bore-holes and mines consists of a bucket reciprocating in a working barrel above a fixed bottom valve, with which latter there is very frequent difficulty. This most vital part of the pump is, as a rule, the part most subject to violent shock and consequent breakdown, while, at the same time, to add to the difficulty, it is always extremely inaccessible.

In the " Ashley " pump there is no bottom valve. The only working part is a single bucket reciprocating in the ordinary way in a working barrel. In this bucket are mounted the delivery and suction valves, so that when any examination has to be made the whole of the working parts are drawn through the rising main to the surface of the ground.

The action of the pump is simple. On the up stroke the delivery valve (D V) is closed and water is lifted. At the same time the suction valves (S V) open, and water pours into the interior of the bucket and lower part of working barrel. Upon the down stroke the delivery valve opens and the suction valves close, and the bucket sinks to the bottom, ready to begin another up stroke, and so on.



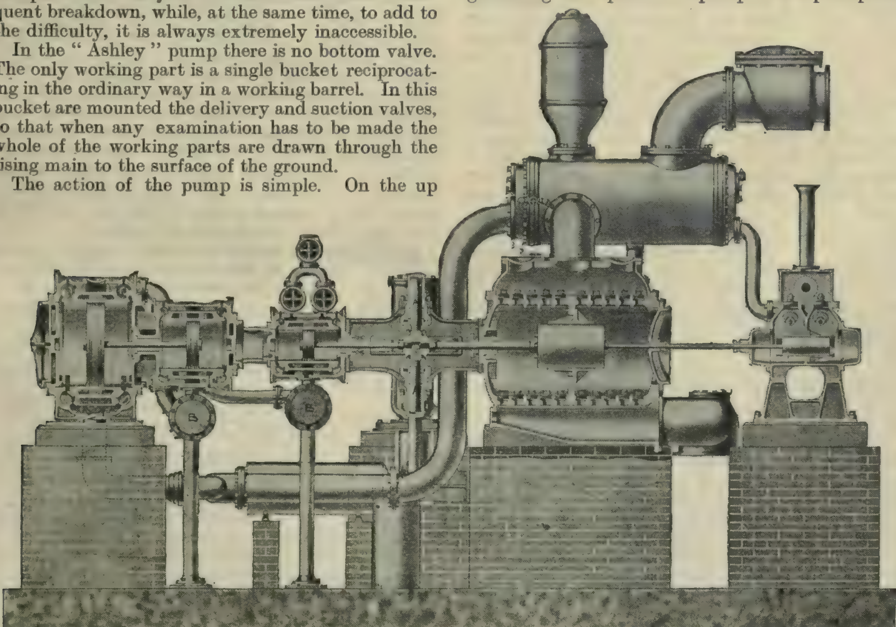
20. THREE-THROW PUMP

The large waterway available in these pumps permits them to be worked at high speeds.

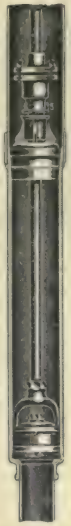
There are two distinct types of the "Ashley" pump. One [25] is the ordinary type for general work, while 27 illustrates the type employed where it is desired to work on suction—that is, to pump the water below the level of the pump barrel, such as in sinking operations. The latter, however, is rarely used. The bucket employed with both types is the same, and is shown by 26.

Figure 28 depicts a three-throw pump made by Messrs. Robert Warner & Co. The diameter of the pump is 4 in., with a 9-in. stroke, and is capable of raising 2,000 gallons per hour, against a head of 200 ft.

Speed of Pumps. The number of revolutions per minute to which a pump should work must depend on its construction. The chief thing governing the speed of a pump is the promptness

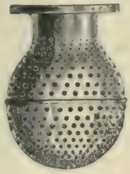


21. NEW FORM OF WORTHINGTON PUMP AT EAST LONDON WATERWORKS

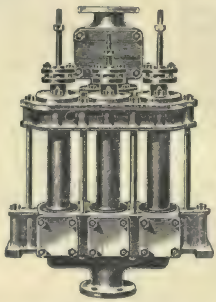


22. Bore-hole pump

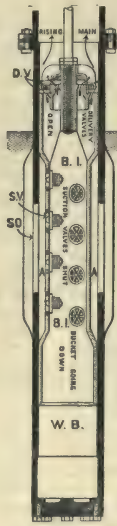
23. Foot valve and strainer for bore - hole pump



24. Strainer for suction pump

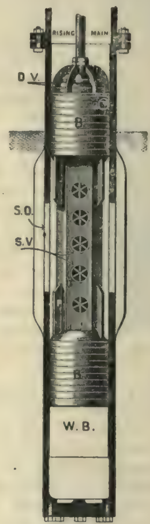


28. Three-throw deep-well pump



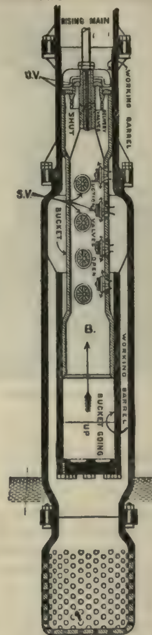
D V–Delivery Valves.
S V–Suction Valves.
S O–Suction Openings.

25. Ashley pump



W B Working Barrel.
B–Bucket.
P–Guide Ribs.

26. Bucket of Ashley pump



27. Suction type of Ashley pump

PUMP DETAILS

with which the valves reseat themselves on the beginning of the return stroke. With multiple valves, which give a large waterway, with small lift, quick reciprocation may be secured. But pumps of the "bucket" type do not admit of multiple valves, and therefore require a pause at the end of the stroke to allow the valves to reseat themselves without undue shock. It is therefore necessary with pumps of this type to have a high bucket speed, which is obtained by lengthening the stroke.

The chief difficulty in working pumps is that of keeping the valves, etc., watertight, and it is here that plunger pumps are superior to piston and bucket pumps. The speed, therefore, should not exceed 30 revolutions per minute, but the average speed for ordinary working may be taken as about 25 revolutions per minute.

The speed at which a centrifugal pump should be run increases approximately as the square of the height of lift. The revolving wheel has to overrun the flow in that increasing degree, while the effect due to impact falls off with the increasing velocity of the wheel. High-speed centrifugal pumps attain a velocity at the impeller periphery of 40 ft. per second.

In selecting the best type of pumping engine to be adopted for any particular place consideration as to working cost must not be forgotten. Professor Unwin, in his Howard Lectures on the "Development of Power," reduced all costs to one common standard—namely, "the cost of one pump horse-power maintained day and night continuously for one year, such horse-power being neither nominal nor indicated, but an actual 33,000 ft-lb. of work measured in water raised per minute throughout the year." The advantage of this is that, having determined the height of lift, the cost per 1,000 gallons of water pumped can be estimated.

The "duty" of pumping engines is expressed by multiplying the weight in pounds of water raised by the pumps by the height in feet to which it is raised for the consumption of a given quantity of coal in the boilers. It is usual in specifying for pumping plants to require the makers to guarantee a certain "duty" for their plant, which is to be stated as the number of pounds of water raised 1 ft. high per hour by 112 lb. of coal consumed in the boilers, on the basis of 10 lb. of water being evaporated per 1 lb. of coal. This coal unit is sometimes made 100 lb. instead of 112 lb. Taking the 112 lb. unit the "duty" is calculated as follows:

1 horse-power = 33,000 lb. raised 1 ft. in 1 minute.
" " = 33,000 × 60 lb. raised 1 ft. in 1 hour.
" " = 1,980,000 ft.-lb. per hour.

Introducing the coal unit of 112 lb., and dividing it by the coal consumed per horse-power hour, we obtain a fraction which, if multiplied by the total foot-lbs. per hour developed, will give us the "duty" as follows:

$$\text{Duty} = \frac{112 \times 1{,}980{,}000 \times 60}{\text{lb. of coal consumed per h.-p. hour.}}$$

As the duty is always expressed in millions, the formula becomes:

$$\text{Duty in millions} = \frac{221{\cdot}76}{\text{lb. of coal consumed per h.-p. hour.}}$$

In the early days of pumping plant a duty of 60,000,000 was considered good. With the increase of steam pressure and the use of compound and triple expansion engines, a 100,000,000 to 120,000,000 duty is quite usual at the present time, and may indeed be exceeded when it is desirable.

PUMPS *concluded; followed by* HARBOURS AND DOCKS

TANNING & MEDICINAL BARKS

Oak and Wattle Tanning Barks. Tanning Extracts. Peruvian Bark and its Febrifuge Principle—Quinine. The Sacred and Lesser Barks

continued from page 5898

THE various natural products used in tanning leather depend upon the presence of tannin, and yet tannin used alone is not a suitable substance for making leather, the success of the operation depending on the other ingredients which occur naturally with it. It is on this account that the various tanning agents produce different kinds of leather, the product of different countries and tanneries having characteristics that depend on the agent used in making the leather. The most important group of tanning agents is that which includes oak and wattle barks. Oak, which is the oldest known tanning agent, is first described, while the cultivation of wattle is given at some length, because it is a suitable industry for establishing in many of the countries of the globe, and is very profitable on cheap land.

The collection of barks used in medicine is, in the aggregate, an important industry. Although some of the barks are used in comparatively small quantities, others, such as cinchona, are important articles of commerce; and various barks are used in the culinary arts as well as in medicine.

Oak Bark. The tanning substance *par excellence* is oak bark, its superiority being said to be due to the fact that it yields its tannin under the most favourable conditions, and so gradually that the tanning matter penetrates and combines equally with the tissues of the skin. The slowness of the process is one of the reasons why other tanning agents are substituted or mixed with oak bark. The varieties of *Quercus robur*, from which oak bark is obtained, are *Quercus sessiliflora* and *Q. pedunculata*; in France, *Q. ilex* and *Q. touzza*; in the United States, *Q. rubra*, *Q. velutina*, and *Q. alba*. China and Japan also have oak forests from which tanning bark is obtained. The quantity of tannin in oak bark varies from 8 per cent. to 14 per cent. Stripping takes place between April 15 and June 15, the bark being easier to separate when the buds begin to swell and the first leaves appear. Mild, damp weather is best, and the morning preferable to evening. The barking is thus performed: Two circular cuts are made at the foot of the tree about 2 ft. to 3 ft. apart, then by using the peeling iron [7] vertical cuts are made to connect the horizontal bands and form the bark into strips. By means of the peeling iron the end of the strip of bark is detached, and by pulling this end the piece of bark readily comes from the tree. This process is repeated till the trunk is denuded, when the tree is cut down and the branches stripped. Cutting takes place when the tree is twenty years old. The bark is dried by spreading on the ground on twigs and brushwood, and afterwards stacked in such a way that the bark cannot be injured by rain. The bark is divided into classes, and each kind is separately broken up into pieces and packed in bags or cases for sale, a riddling process being first gone through to separate out the foreign matter. An acre of oak underwood twenty years old yields from 3½ cubic yd. to 8 cubic yd. of wood; each cubic yard of wood from 75 lb. to 110 lb. of bark.

7. PEELING IRON

The Wattle-tree. The bark of the wattle-tree has long been used for tanning leather, but it is only comparatively recently that it has been systematically cultivated. The wattles are natives of Australia, at least 312 species being known, all of which contain more or less tannin, but only three are sufficiently rich in tannin to be worth cultivating. These are: *Acacia pycnantha* [8] (South Australian broad-leaved wattle); *A. decurrens* [9] (Sydney black wattle); and *A. mollisima* (Tasmanian and Victoria black wattle). The two first named are those recommended for cultivation. *A. pycnantha* shows a range of 28·5 to 46·47 per cent. of tannin, the range in *A. decurrens* being from 15 per cent. to 36 per cent. The latter is a more rapid grower, but *A. pycnantha* is hardier.

Planting Wattles. Baron von Mueller recommended the planting of wattles on worn-out lands in Victoria, but the soil for preference should be sandy, with a clay subsoil. On limestone formation the bark of the tree is inferior in tannin, but the trees grow well in such a soil. In California lime soil is employed, and in Natal virgin grassland with light red friable loam over gravel and clay is found to answer admirably. The trees succeed well under an annual rainfall of 16 in. to 20 in., but unlimited moisture is thought to make the bark deficient in tannin. Wattles will not stand more than from six to eight degrees of frost.

Wattle seeds are very small and hard. There are from 20,000 to 30,000 of the seeds to the pound, and they are so hard that if placed in the ground without preparation they would remain dormant for years. It is usual to prepare the seeds by heat. The seeds are either (1) roasted in a frying pan; (2) covered with boiling water and left till soft; or (3) mixed with hot ashes obtained by burning brushwood. The prepared seeds are next mixed with sand and planted in drills. The seeds should not be covered too deeply with soil—one inch deep is ample—and if only sparingly sown will lessen expense for transplanting. The seedlings are transplanted when one year old to their permanent position. In ten years from sowing the seed the wattle-tree is in its prime, but the trees are old enough to bark in their seventh year when they are 5 in. or 6 in. in diameter. The bark of the tree is richer in tannin than the branches,

8. ACACIA PYCNANTHA

but the whole tree is bared of bark at the same time. Peeling can be carried on at all times of the year in some parts of the world, but in Australia the best time is when the buds are swelling.

Barking the Wattle. With a short-handled axe the dead twigs and leaves at the base are cleared away and a cut made into the bark as near the ground as possible. The barker then lifts the edge of the bark, and by a series of strong jerks peels off a broad strip as long as the height from the ground to the first branches of the tree [10]. Strip after strip is pulled from the trunk until it stands as bare as a telegraph pole. The tree is then felled, and the work of stripping completed on the branches. The fresh bark is thrown over poles to dry and the trunks are cut up for mining timber. A portable tramway through the plantation conveys the bark to the drying sheds, which are simple but ingenious galvanised iron affairs, in which six tons of bark can be sheltered. The long strips of bark are hung on poles, and the ends of these poles are put through rings in two heavy chains that hang from two parallel bars. A series of these poles loaded with bark is fitted to the rings a foot or two apart in the chains, and one by one they are put across the parallel bars with their ends resting upon them. In fine weather these poles with their loading of bark remain hanging on the long bars, but on the approach of rain a yoke of oxen is attached to the chain of poles by a wire rope, and, like the shutting up of the bellows of an accordion, these poles are drawn close together down the parallel bars into the shelter of the corrugated iron roof.

9. ACACIA DECURRENS

The value of the bark depends largely on its colour, this being best preserved in the process of sun-drying just described. The bark is sent into commerce in three forms: (1) in bundles; (2) chopped into short chips; and (3) ground to fine or coarse powder. Fine grinding is not recommended, as the powder is difficult to mix with water in that state.

Yield of the Wattle-tree. Various estimates have been published as to the yield per tree and profit per acre on wattle growing. They naturally vary with the value of the soil and the cost of labour. Mr. J. E. Brown, a South Australian expert, estimates that an acre of land should raise about 10,000 trees, which, at six or seven years, would yield 15 lb. of bark each—7 tons of bark per acre. A better yield would be obtained by allowing part of the trees to mature, the first harvestings being in the nature of thinnings. Mr. Brown stated that 100 acres should show a profit of over £1,000, besides paying 7 per cent. upon the money expended from putting in the seed to barking. The purchase price of the land was taken at £23 per acre. Mr. J. H. Maiden, another authority, estimates that the profit, eight years from planting 100 acres of wattle, would be £2,550, after making full allowances for rent, interest, and all possible expenses. In Natal the cost of stripping, drying, and packing the bark amounts to 30s. per ton. At the Town Hill plantation near Pietermaritzburg sixty men are needed for 2,400 acres. The estimates of yield per tree given above are very conservative, as Mr. J. E. Brown states that he has stripped as much as 320 lb. of bark from one tree of *A. pycnantha*, and nearly half a ton from a tree of *A. decurrens*.

10. STRIPPING WATTLE BARK

Hemlock Bark and Extract. This is the favourite source of tannin in North America, and is obtained from *Tsuga canadensis* (Linn.) Carr., and *T. heterophylla* (Raf.) Sarg. Hemlock bark contains 8 to 10 per cent. of tannin, whilst the extract, the form in which it is exported, contains 20 to 30 per cent. of tannin. The peeling extends from May to August, but the tree peels easiest from June to the middle of July. The peeling crew consists of three men—a chopper, preparer, and barker. The chopper, or faller, cuts down the tree; the preparer, or fitter, trims off the branches and rings the bark at intervals of 4 ft., and slits each section lengthwise; while the spudder, or barker, peels off the bark with a flattened bar and spreads it on the ground with the inner side up. After the bark has cured in the sun for from five to ten days it is piled, exterior side uppermost, to complete the seasoning process, which altogether occupies from two to three months.

Many tanning barks are supplied in the market in the form of an extract, a concentrated preparation which saves freight. The bark is ground and placed in wooden vats, where it is steeped in water till the tanning acids are removed. The resulting liquor is then evaporated in a vacuum apparatus at 180° F. until it is reduced to a heavy, dark-coloured fluid, weighing 10 lb. to the gallon. The extract is shipped in barrels of 500 lb. The plant for making extract is expensive, and in the case of small growers a share in a co-operative factory is obviously the solution of the problem.

Other Tanning Barks. Mangrove bark is yielded by several varieties of a small evergreen tree that is found on the muddy shores and tidal creeks of India, Burma, and the Andaman Islands. The chief kinds are: *Avicenna officinalis*, Linn. (white mangrove); *Bruguiera gymnorhiza*, Lamk.; *B. parvifolia*, W. and A.; *Ceriops candolleana*, Arnott (black mangrove); *C. Roxburghiana*, Arnott; *Kandellia Rheedii*, W. and A.; and *Rhizophora mucronata*, Lamk. (true mangrove). Extracts of the bark of these trees are made for exportation. Large quantities of tanning extracts are also obtained from the wood and bark of the chestnut tree, *Castanea dentata* (Marsh) Borkh.; the chestnut oak, *Q. prinus*, Linn.; the larch, *Larix Europea;* the alder, *Alnus glutinosa;* various kinds of willow; the fir, *Abies excelsa*, and the pine-tree.

It should be noted that we are only dealing here with tanning barks; many other substances yielding tannin are also used in the leather industry.

Of recent years the importance of medicinal barks has been recognised, and care is being taken by cultivation to develop a lucrative branch of economic botany. London is the drug market of the world, the crude drugs from all parts of the world being sold at Mincing Lane fortnightly. In the following notes the general methods of cultivating and collecting barks will be judged from the article on cinchona, which is given at length on this account, and also because of its importance as a medicinal bark.

Peruvian or Cinchona Bark. One of the most important drugs is cinchona, or Peruvian bark, from which quinine is obtained. Quinine, and its cognate alkaloids, have hitherto been found only in the barks of the genus *Cinchona* [**11**] and the allied genus *Remijia.* These are found only in a limited zone of the eastern slopes of the Andes, and nothing was known to Europeans of their medicinal properties till some time after the Spanish conquest. In 1638 the wife of the Count of Chinchon, Viceroy of Peru, was cured of malarial fever by the administration of a hitherto unknown remedy, and she took great pains to introduce its use in Europe. Hence the name of the genus, which purists spell "chinchona." An alkaloid (active principle), cinchonine, was isolated by Gomes in 1816, and in 1820 Pelletier and Cavantou isolated quinine.

Until fifty years ago the world depended for its supply of cinchona on the "cascarilleros" of the South American forests. They ruthlessly felled or carelessly barked the trees, with the result that the diminished supply fell short of the ever-increasing demand. In British India there was not only a great demand for quinine but climatic conditions very similar to those on the Andes, and the Government wisely determined to set about the introduction of cinchona into the country. It was no easy matter, as anyone suspected of an attempt to carry off plants or seeds from the South American forests went in peril of his life. A few plants were obtained through consuls in 1852, but they died as soon as they reached India. Sir Clements Markham, in 1859, aided by Spruce, R. Cross, Pritchett, and J. Weir, obtained plants and seed which were successfully reared in India. In 1865, Charles Ledger, after a lot of trouble, obtained seeds of a species of cinchona which yielded a much larger proportion of quinine than those obtained by Markham and his coadjutors. Ledger divided his seeds between the British and Dutch Government. The former did nothing with the seed, whilst the Dutch raised plants in Java which proved so rich in alkaloid that the descendants of those trees are the main source of quinine to-day.

11. THE CINCHONA PLANT

Kinds of Cinchona. There are thirty or forty species of cinchona, but most of them are of botanical interest only. The kinds now cultivated are *Cinchona officinalis*, Loxa or crown bark; *C. succirubra*, red bark; *C. calisaya*, yellow bark; *C. Ledgeriana*, a cultivated variety of *calisaya*. Very little cinchona is now obtained from South America, quinine-yielding bark coming from Java, where *C. Ledgeriana* is cultivated, and from India, where *C. succirubra*, known as druggists' bark, is grown. Manufacturers use the Java bark on account of its richness in quinine, but the succirubra bark is that required in medicinal preparations by the British Pharmacopœia. It costs no more to cultivate trees rich in alkaloid; hence the Java bark, being the richest, rules the world's supply. Java bark sometimes contains 15 per cent. of quinine, against 3 per cent. in the Indian-grown bark.

Cultivation. Cinchona plants will not stand frost, and grow best at altitudes of from 1,500 ft. to 4,500 ft. They require open subsoil, sloping exposure, and other conditions of perfect drainage. The plant will not grow on flat land. It is propagated by cuttings or seeds. The former method is used when it is desired to perpetuate a particular feature of a plant, but now the seed is readily obtainable it is used. The seeds are very small, and cost from 5s. to 6s. a gramme, about 2,500 seeds. A perfected small tree of high quinine content costs 17s. The seeds germinate best at a temperature of between 65° and 70° F. They are sown in open beds, sheltered by thatched roofs. Fine, rich, well-decayed mould is employed, either pure or mixed with an equal part of clean, sharp sand; a layer 2 in. to 3 in. deep is spread over a piece of well-cleaned, sloping land.

The surface of the seed-bed should be smooth and even, and the seeds scattered pretty thickly on the surface and afterwards a little fine earth sprinkled over. Water freely with a fine syringe. The seeds germinate in from two to six weeks, and when the seedlings have grown two or three pairs of leaves they should be transplanted into nursery beds having a thicker layer of soil and placed about 1½ in. apart. When 4 in. high the plants are again transplanted a little further apart, and when 9 in. to 12 in. high they are ready for placing in the position they are to occupy finally. It is usual now to place the plants 6 ft. to 8 ft. apart.

Collecting the Bark. Formerly the only method of collecting the bark was to cut down the tree and strip off the bark from the stem, root and branches; but in 1863 it was discovered by McIver, who had charge of the Indian cinchonas, that if a portion of the bark of a living cinchona be carefully removed so as not to injure the young wood of the tree, the removed bark will be gradually renewed. The renewed bark is richer in alkaloid than the bark removed, and exclusion of light tends to increase the richness. In Madras an ordinary pruning knife is used, and in Java a spokeshave [**12**], to take off alternate strips of bark in a longitudinal direction. The trunk is then covered up with moss [**13**]. Three years after, the strips of bark that were left at the first harvesting are taken off, and so on in alternate three years until the tree dies or becomes too old to renew its bark. The bark, after it is removed, is placed on "panagans" or bamboo trays, and dried in the sun. A movable roof or other protection against rain is provided. The moist climate of Java prevents the drying being completed naturally and a sirocco stove, such as is used in tea plantations, is employed to finish the process. The strips lose about 70 per cent. on drying.

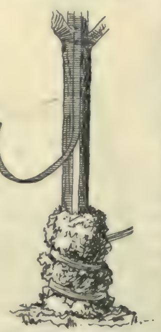
Marketing Cinchona. The two kinds of bark are druggists' and manufacturers'. In the former variety the bark is packed in gunny bags, forming bales containing 100 lb. each, whilst in Java much of the bark is reduced to coarse powder before shipment. In the case of druggists' bark, the appearance of the drug has to be considered; it must be in bold, long, regular quills, and be coated with a silvery coating of lichens. The bark which manufacturers employ is made up in large bales and

sold at Amsterdam at so much per unit—the cost of each percentage of quinine in a pound of bark. For this purpose analyses are conducted. The low price of quinine and the competition of Remigia bark, which contains quinine in an easily extracted form, has made cinchona cultivation so unprofitable in India and Ceylon that on most of the plantations it has been replaced by other more paying crops. The Government of India, however, have their own cinchona plantations, and make quinine for distribution in malarial districts at cost price. The "febrifuge," as it is called, contains the other cinchona alkaloids besides quinine, and its distribution has been of enormous service to the inhabitants of the Indian Empire.

The Sacred Bark. Cascara sagrada, or sacred bark, is the dried bark of *Rhamnus purshianus*, De C., a tree which grows freely in North California and in the States of Oregon and Washington, U.S.A. The bark and its preparations are much used in medicine as aperients, and it is curious that the drug is a modern introduction. It was not till 1887 that the bark became a recognised article of trade. The bark is peeled in both summer and winter, and as the tree is destroyed in the process, it is not surprising that the drug is becoming quite scarce, although its use is increasing. Recently, attention has been drawn to the matter, and plantations are being made for the systematic cultivation of cascara sagrada. One variety of the bark is simply removed from the stem by a knife or spokeshave [12], whilst the other is obtained in the same way (in winter) after a preliminary steaming to loosen the bark. Much importance is attached to the proper drying of the bark, the strips being hung over galvanised wire with the inner surface away from the sun. Should the inner surface be exposed to the sun while in the moist state, the colour of the bark changes from its natural yellow to a dark brown, which renders the drug less marketable. After the bark is dried it is broken into pieces by passing through a machine or, failing that, a flail is used. The average yield of a tree is 10 lb., so that the annual demand of a million pounds means the destruction of 100,000 trees. When propagated from seed, the tree is slow in growth, but attains in time a height of from 25 ft. to 65 ft. and a diameter of 5 in. to 8 in. New bark does not form on the trunks, as in cinchona.

12. SPOKESHAVE

Cascarilla, Cinnamon and Cassia. Cascarilla is a drug of minor importance, but of considerable interest from the fact that as the plants from which it was collected became extinct, the collectors have gathered bark in the other districts from apparently similar plants. Cascarilla bark is at present yielded by *Croton eluteria*, Bennet, and is indigenous to the Bahama Islands. The bark is taken from the twigs, branches, and small stems. It is used in medicine as an aromatic bitter tonic, but its chief use is as a scent in tobacco manufacture, in the preparation of incense, and in liqueur making. When burnt, cascarilla gives off a pleasant odour.



13. MOSSED CINCHONA TREE

Cinnamon is the dried inner bark of shoots of several species of *cinnamomum*, Blume, small trees indigenous to Ceylon, the bark being obtained from cultivated trees. The shoots are cut down when nearly two years old and the bark removed in strips. This bark is then scraped free from the outer bark, rolled into sticks, and dried. The bark is used in medicine and as a flavouring agent. *Cassia* bark resembles cinnamon in odour and taste, but the aroma is less delicate.

Angostura, Euonymin, and Barberry Barks. *Cusparia*, the dried bark of *Cusparia febrifuga*, De C., is indigenous to the mountains of Venezuela. It is known as angostura bark because it was originally sent from Angostura (Ciudad Bolivar) to Europe. The bark is not easy to detach from the tree and is often found with much wood adhering.

Euonymin bark is stripped from the root of *Euonymus atropurpureus*, Jacquin, which grows in shady woods in the eastern United States. The bark possesses cathartic properties.

Barberry bark is obtained from the stem of *Berberis vulgaris*, Linné, a European shrub. It is used as a febrifuge and for dyeing.

Other Medicinal Barks. *Pomegranate bark* is obtained from the stem and root of *Punica granatum*, Linné, a small tree that grows in North-West India. It is cultivated on the Mediterranean coasts for its fruit. The bark has astringent properties and is used in medicine to expel tapeworms.

Hamamelis, or *Witch Hazel bark*, is collected in the spring from *Hamamelis Virginiana*, Linné, which grows in the United States and Canada.

Virginian Prune, or *Wild Cherry bark*, is collected in autumn from a North American tree, *Prunus serotina*, Ehrhart. Although the bark is collected from all parts of the tree, that which comes from the trunk is the best. The bark is used in medicine for its tonic and sedative effects.

Quillaia, *Panama*, or *Soap bark*, is the inner bark of *Quillaia saponaria*, Molina, which grows in Chili and Peru. When shaken with water the bark gives a froth like soap, and on this account is used in the textile industry when soap is inadmissible. In pharmacy, quillaia is used to suspend oils, and in the aerated water industry a trace of quillaia gives a delightful froth to beverages in which it is introduced.

Elm bark, from the common elm, *Ulmus campestris*, Linné, is collected from the trunk and branches in the spring. It possesses tonic properties. Slippery elm bark is obtained from *Ulmus fulva*, and it is used, after soaking in water, as a poultice.

Willow bark, *Salix alba*, Linné, yields salicin, a medicine much used for rheumatism. The bark contains 1 to 3 per cent. of salicin, but some varieties are nearly destitute of this active ingredient.

Simiruba bark is obtained from the root of *simiruba amara*, Aublet, and *S. glauca*, De C. The bark is used as a tonic.

Mezereon bark is obtained from *Daphne mezereum*, Linné, *D. laureola*, Linné, and *D. gridium*, Linné. It is obtained both from root and stem, and is used as a stimulant associated with sarsaparilla.

Canella bark is yielded by *Canella alba*, Murray. It is used in medicine and as a condiment.

Continued

HORIZONTAL & THREE-CYLINDER ENGINES

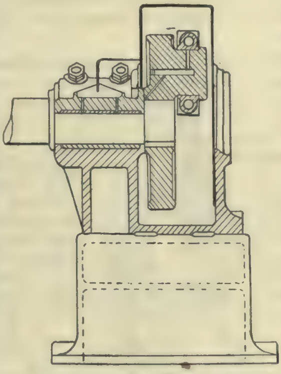
Horizontal Engine with Splash Lubrication. Compound Condensing Engine. Three-cylinder Engine. Mechanisms of Expansive Working

Group 24
PRIME MOVERS
5

Continued from page 5914

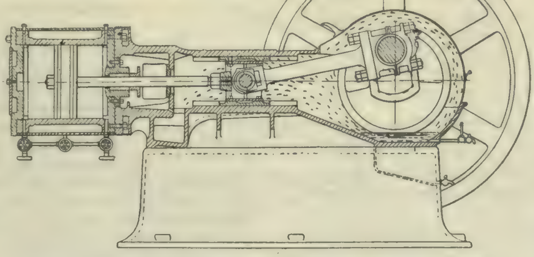
By JOSEPH G. HORNER

AUTOMATIC lubrication, illustrated in the last article, is applied to horizontal as well as to vertical engines, though on first thoughts the horizontal type would not appear to be well adapted to the system. Figure **34** shows a longitudinal section through one of the "Fleming" engines, by the Harrisburg Foundry and Machine Works, of Pennsylvania, in which lubrication is effected on the splash system. A supply of oil is poured into the engine frame, forming a reservoir in which the lower edge of the crank-disc is always submerged. When the engine is started the revolving disc throws the oil from the reservoir backwards over the crosshead and into the guides. It also throws a spray into a trough placed across the inside of the hood that confines the oil. Thence a short tube conveys the oil to a point over the main bearing [**33**], to which it flows in a constant stream which is always visible to the operator. An eccentric groove is cut in the face of the crank-disc which comes next the bearing, and into which the oil finds its way. From the point of greatest eccentricity a passage is provided to the centre of the crank-pin, which is hollow, and from which the lubricant is driven by centrifugal force to the bearing. The pin and disc are made solidly, and the pin is of exceptionally large diameter.



33. LUBRICATION OF CRANK-PIN IN FLEMING ENGINE

Experimental Engine. A typical high-class engine [**35**] illustrates one selected because it embodies a large amount of detail that is crystallised in the best modern practice. It is, moreover, what is termed an "experimental engine," being made for the Cambridge University by Messrs. Robey & Co., Ltd. The full technical title of this class of engine is, "long-stroke, tandem compound, condensing engine with drop valves." Engines of this type are made for powers up to 3,000-horse power, with steam pressures ranging to over 200 lb. per square inch, and with triple expansion cylinders. The term "tandem compound" relates to the arrangement of the high and low-pressure cylinders, which have their axes *in line*. If placed side by side, they would be termed *coupled*, or *cross-compounds*. The advantage of the tandem is, that one piston rod does duty for both pistons. Coupled engines have the advantage that their crank-pins stand at right angles with each other. The tandem occupies less width, but greater length. It is a very popular form.



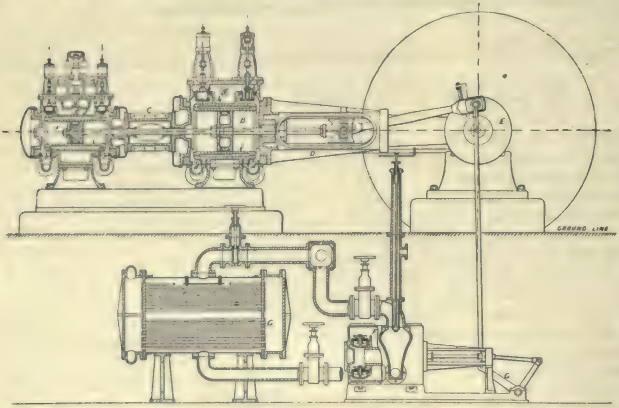
34. FLEMING ENGINE WITH SPLASH LUBRICATION

In **35**, A is the high-pressure and B the low-pressure cylinder. These are different diameters, but necessarily of equal stroke, and connected with the distance-piece C, which is a rigid casting. The ratio of cylinder diameters is approximately 3 to 1. The crosshead guide D is of the cylindrical type. The crank-disc E, keyed on the flywheel shaft, also drives the condenser air pump F, through the bell-crank lever, or *bob* G. This arrangement is common in many large engines, its alternative being to drive the air-pump from the tail end of the piston-rod, as in **30** [page 5913], which in that case is carried out at the rear of the hinder cylinder. The arrangement shown, in which the air pump is placed underground, economises floor space.

Condenser. The condenser G is of the *surface condensation* type. The exhaust steam and cooling water are in circulation on opposite sides of the walls of the condensing tubes. These tubes distinguish this type from the *jet* condenser, in which a jet of water is pumped into a box into which the exhaust steam is admitted. This is a more suitable type when water is muddy or dirty, but the surface condenser is more efficient. The water circulates through the tubes, which are surrounded by the steam. The water in this case is delivered by pressure by the town's main, but generally this is the function of a circulating pump, which is of reciprocating or a centrifugal type, an example of which will be given in connection with marine engines.

Condensation in the Condenser. The efficiency of a condenser is due to the vacuum produced therein by the injection of cold water among the exhaust steam in the jet type of condenser, or the circulation of water in closed tubes among the steam in the surface type of condenser. The effective pressure on the piston when exhaust takes place into a condenser instead of into the air, is increased by from 10 lb. to 12 lb. per square inch, because the vacuum amounts to 10 lb. to 12 lb.—that is, from 10 lb. to

12 lb. of the pressure of the atmosphere has been destroyed in the condenser. Say the vacuum is 12 lb. below the atmospheric pressure, then, instead of the steam exhausting into the atmosphere when at 15 lb. or a little more, it does not exhaust till it



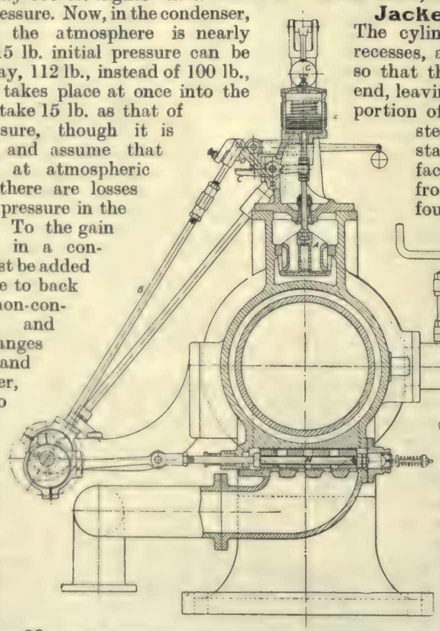
35. TANDEM COMPOUND CONDENSING ENGINE (Robey & Co., Ltd.)

gets down to 3 lb. To understand this, it must be remembered that the steam pressure in a boiler is always that within the boiler plus that of the atmosphere, so that steam blowing off at 115 lb. by the gauge is only 100 lb. higher than that of the atmospheric pressure. Now, in the condenser, the resistance of the atmosphere is nearly destroyed, and 115 lb. initial pressure can be utilised down to, say, 112 lb., instead of 100 lb., when exhaustion takes place at once into the atmosphere. We take 15 lb. as that of atmospheric pressure, though it is actually 14·7 lb., and assume that steam exhausts at atmospheric pressure, though there are losses due to the back pressure in the exhaust passage. To the gain due to vacuum in a condensing engine must be added that of the loss due to back pressure in a non-condensing engine, and which generally ranges between 1 lb. and $1\frac{1}{2}$ lb. Moreover, the gain due to condensation is less than the theoretical amount, because the loss due to the friction of the air pump has to be deducted from it, so that the net gain is reduced to, say, 8 lb. or 10 lb. on the square inch. This, however, is a very substantial gain in engines of medium and large dimensions, amounting to from 15 to 20 per cent. saving in fuel.

Feed-water Heater. A subsidiary benefit of condensation is that the boiler feed is delivered from the hot-well at a temperature of 100° F., or more. Cold water injection damages the plates of boilers, besides requiring more fuel for heating, than if delivered at a temperature approaching the boiling point. Boiler deposit is also less likely to occur. In non-condensing plants some methods of heating the feed-water are necessary, which is effected in *economisers*, and in *feed-water heaters*. In the first, the furnace gases heat the water in their passage to the chimney. In the second the exhaust steam heats it before being discharged into the atmosphere.

Action of the Steam in the Engine. The steam, after doing work in the high-pressure cylinder A [35] is carried by receiver pipes (not shown) to the low-pressure cylinder B. It works expansively in both cylinders. In the high-pressure, the steam inlet valves are those at *aa*; in the low-pressure, at *bb*, being *drop valves* in each case. The exhaust valves in the high-pressure are *cc*, and the low-pressure *dd*, both being of the sliding gridiron type. The steam inlet to the high-pressure is at *e*, and *f* is its steam chest; the inlet *g* is that for the low-pressure, and *h* is its steam chest, or receiver.

Jacketing. Both cylinders are jacketed. The cylinder bodies are cast with annular recesses, and the liners *ii*, also have recesses, so that the liner and body fit by belts at each end, leaving an annular space along the greater portion of their length which is occupied with steam. This jacketing, as already stated, lessens loss of heat, and the liquefaction that would otherwise result from condensation. Three out of the four covers are also formed as jackets through which steam circulates. When the exhaust steam leaves the cylinder B it passes into the condenser below.



36. TRANSVERSE SECTION THROUGH VALVE GEARS OF ROBEY ENGINE

Drop Valves. The valve gears in this engine are a neat bit of mechanism. The sectional view in **36**, taken with those in **35**, will render their operation clear. On the farther side of the engine there is a rod *a* [36] rotated from the crank-shaft, which carries eccentrics from which the valves are actuated. This "lay shaft" and eccentrics is a very common device in engines by different makers, but the mode of operating the valves therefrom here illustrated is one of Robey & Co.'s patents.

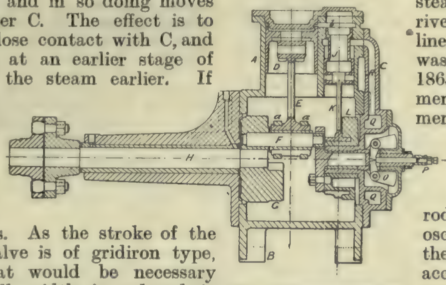
In **36** the steam inlet valve A is actuated by the eccentric rod B depressing the outer end of the lever C, so raising the valve by its stem. This is timed to take place before the beginning to each stroke. D is a tripper which communicates the motion of B to C. At a certain point the tripper slips out of contact

with C, and the valve is thrust down sharply by the dash piston F above, so cutting off the steam from the cylinder. But the valve is combined with a governor G, by which the period of cut-off is varied with alterations in the load on the engine. The governor when rising, caused by increase in speed, moves the arms of levers, and in so doing moves the fulcrum E of the lever C. The effect is to cause the tripper D to lose contact with C, and allow the valve to drop at an earlier stage of the stroke, so cutting off the steam earlier. If the governor falls the drop of the valve is delayed, and the steam is cut off at a later stage. The exhaust valve H at the bottom has a constant travel, operated from other eccentrics and rods. As the stroke of the eccentric is short, the valve is of gridiron type, by which the stroke that would be necessary for a single port of full width is reduced in proportion to the number of smaller ports in the gridiron. The valve H is operated by its own eccentric. Drop valves similar to those for steam are also often employed in engines for exhaust.

Simple Coupled Engines. Horizontal engines are frequently coupled by taking two independent single-cylinder engines and arranging them side by side, each on its own foundation, and each driving in unison to a common flywheel between the two. One advantage of this arrangement is that less space is occupied than would be required by a single engine of equal power. The length is that wanted for a single engine of the coupled pair, and the width is but about one-half more than that required for one of the engines, while the power is doubled. Another, and the principal, advantage is that the engines can be run in unison, or either one singly, disconnected from the other at the connecting-rod. One may be running while the other is undergoing repairs, or one or both may be run to suit work which varies in amount. Moreover, in this design one engine can be laid down first, and the second added at a later period if circumstances should render additional power necessary. The same remark applies to compound engines laid down side by side. The high-pressure one can be put down first, and the low-pressure, for compounding, later. And the high-pressure can at any future time be run alone, on disconnecting the other engine.

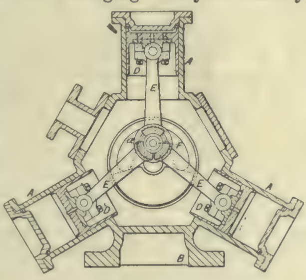
Inclined Engines. The immense majority of engines built are either horizontal or vertical. But exceptions occur in inclined engines, which have their axis of cylinder and guides set at a considerable angle. They are used chiefly in paddle steamers for river and coasting service, where the space between the deck and the floor of the engine-room is not sufficient to allow vertical engines of the dimensions required to be got in. Double inclined engines are also used in some rolling mills. These engines drive in opposite directions on to a common crank at the apex of the arrangement.

Oscillating Engines. A type by itself is the oscillating engine, an old form built chiefly for paddle steamers, but seldom now made. These engines were great favourites in the early days of steam navigation, especially on river steamers. The last Atlantic liner on which they were fitted was on the Cunarder Cuba, in 1865. They were an improvement on the side-lever engines mentioned in a previous article. The weight was kept low down in the vessel's hull, and all the side-rods and levers, with the connecting-rod, were discarded. For by the oscillation of the cylinders on their trunnions the piston-rods accommodate their movements to that of the cranks. The trunnions are utilised, one for the inlet of steam, the other for its exhaust. Many warships were fitted with this type of engine, but the vertical inverted cylinder engine has long displaced it, both in the naval and merchant services. It has gone the way of other types, whi h, though of much historic interest, are now extinct. They included the trunk engines, both vertical and horizontal, the steeple engines, the grasshopper engines, and others, representing stages in the evolution of the engines of the present.



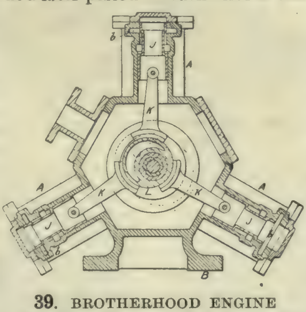
37. BROTHERHOOD ENGINE
(Horizontal section)

Three-cylinder Engines. This is a group of engines which stands alone. Three cylinders, set at angles of 120 deg. with each other, have their piston-rods driving to a common crank-shaft, the rods being pivoted to their pistons. As they exert equal effort on the crank-shaft, there are no dead points, and a flywheel is therefore not required.



38. BROTHERHOOD ENGINE
(Transverse section through cylinders)

The idea of avoiding the reciprocating strokes of the common engines has always been an ideal of engineers. But greater evils have attended many such efforts than those due to reciprocation. The latter have been exaggerated. The engines which run at highest speeds, such as those for electric light work and locomotives, run with perfect steadiness. The steam turbine, though a rotary engine, is, nevertheless, a type apart from piston types, which we are here considering.

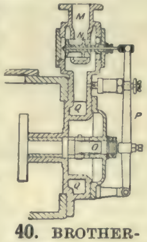


39. BROTHERHOOD ENGINE
(Transverse section through valves)

Brotherhood Engines. These, designed by Mr. Peter Brotherhood, are made for steam, and for air and water operation. The differences are slight, affecting chiefly the valves and their packings. These engines are used for electric light work, for driving portable machines, and for propelling torpedoes. The engine illustrated in **37** to **41** is one of single-acting type. Figure **37** is a horizontal section through cylinders, valves, and crank-shaft; **38**, a transverse section through the cylinders; **39**, a similar section through the valves; **40**, a section

through the throttle and governing gear; and 41, an external view looking against the steam chest.

Brotherhood Cylinders. The cylinders are seen at A. They are in one casting, with a foot, B, but the steam passages are formed in a separate single casting, C, bolted to the cylinder. The pistons D are of trunk design, and their rods, E, are necessarily pivoted loosely in the trunk pistons, driving to the common crank-pin F in the crank-disc G. Thus, though the pistons move rigidly, their rods are free to accommodate themselves to the rotary movement of the pin F in its disc. The latter drives the crank-shaft H, to which the work is coupled. The steam presses only on the outer faces of the pistons, the return or exhaust stroke of one piston being effected by the pressure stroke of the other two. The rods are bonded at the centre with rings, *aa*, to maintain them in contact with the crank-pin, being necessary because each of the rods only bears round a little less than one-third of the circumference of the pin.



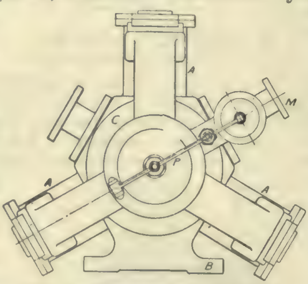
40. BROTHERHOOD ENGINE (Section through throttle and governing gear)

The steam supply is controlled by the piston valves J, the rods K of which are actuated by the eccentric L. These are retained in contact with the eccentric by an undercut fitting, seen clearly in the sectional view [37], in a flanged part of the eccentric. The steam is admitted through the pipe M, the throttle valve N of which is regulated by the governor O acting through the lever P. The steam, having passed the throttle, enters the steam chest Q and passages R, and past the piston valves, through the passages *b* to the ends of the cylinders. There are thus no dead points, and the engine can be started in any position.

Expansive Working. In a previous article the methods of obtaining a fixed rate of expansion have been illustrated. We now consider other devices, including the link motions.

Mechanisms of Expansive Working. On page 5414, Boyle's law was quoted, that the pressure and volume of a gas at constant temperature are inversely related. Let us see how this applies to steam working expansively in a cylinder. If steam supply enters and continues unchecked until the termination of the piston stroke, it is assumed to be at boiler pressure throughout, and the effect is that due to this pressure × piston area × length of stroke in inches. If, however, the steam is cut off at half-stroke, the second half will be accomplished by the expansion of one volume into two volumes, with a reduction of pressure to one-half of the initial pressure by the time the end of the stroke is reached. The mean or average pressure then is, assuming an initial pressure of 100 lb. per square inch,

$$\frac{100 + 50}{2} = 75 \text{ lb. mean.}$$



41. BROTHERHOOD ENGINE (External view)

If cut off at one-third, or one-fourth, the average would be obtained by taking the pressures due to expansion at three, four, or any number of points, and dividing the sum of these by the number of division. But, generally, a shorter method is to use a table of hyperbolic logarithms, given in textbooks, because the line of falling pressure is a hyperbolic curve.

The common D form of slide valve is used less than formerly, because in its simple form it is not adapted to cut off with a high rate of expansion without causing other troubles consequent on the excessive amount of lap required. Moreover, it is not suitable for the automatic expansion effected from the governor. This explains why badly cut-off valves are fitted, and double and treble sorted valves, as previously illustrated, by which the length of travel of the valves is reduced. But, besides this, there is the objection to the length of the steam passages, which, being always filled with steam entering or exhausting, cause either waste of steam or wire drawing, or undesirable back pressure, or accumulation of water in the cylinder and passages. With a view to avoid these evils, two types have been largely developed, the drop valves and the Corliss valves. The only features which these have in common is shorter steam passages than the slide valve engines have, a sharper opening and closing, and a separation of the functions of the passages, those for steam and exhaust being used for those purposes only, instead of being opened alternately to steam and exhaust. Examples of drop valves are illustrated in the present article [36], and Corliss in the next one.

Hand Expansion Gear. Very many engines are fitted with hand-operated expansion gear, using main slide valves, with expansion or cut-off valves sliding on the back. Designs vary. Generally, advantage is taken of this arrangement to make the steam passages in the cylinder short, by which back pressure and other evils are reduced. Thus, in one design, the D valve is divided into two portions, one at each end steam port of the cylinder, each steam port having its exhaust port adjacent. The expansion valves on the back of the D valves are flat plates only on a single rod, having bushes with right and left hand screws and nuts, which engage with screwed bosses on the back of the valves. By a hand wheel at the end of the spindle the valves are caused to approach to or recede from each other, so cutting off steam earlier or later. The period during which steam will be admitted is read on a sliding index close to the hand wheel.

The *Rider* expansion gear is, in brief, designed as follows: There are two slide valves, the main valve, and the back cut-off, or expansion valve, each having its separate actuating eccentric. The peculiarity is that the ports in the valve do not run straight across, but diagonally, and to right and left symmetrically about their centre lines. The reason of the diagonal arrangement of the ports is this:

The ordinary longitudinal sliding movement derived from the eccentrics is invariable. But automatic movements of the governor are made to impart movements to the cut-off valve at a right angle with its longitudinal movement, derived from the eccentrics, so causing the admission of the steam to the diagonal ports to be cut off earlier or later than the normal stroke derived from the eccentric would produce. This up and down variable movement is derived from the governor, which is made to impart a twisting movement to the valve-rod, which, in turn, raises or lowers the expansion or cut-off valve by means of a small crank.

Continued

THE EXACT ART OF MAKING TYPE

Group 19
PRINTING
8

Continued from page 5872

The Art and Trade of Typefounding. Punch-cutting and Matrix-making. Machine Typefounding. Wooden Type. The Best Books on Printing

By W. S. MURPHY

THE fathers of printing in Europe—Coster, Gutenberg, Faust, and Schöffer—were also typefounders or type engravers, but it is difficult to say from the records whether the first printers were regarded, by themselves and others, as makers of type or printers. Wood was, perhaps, the material of which the first movable types were made, but the whole question of the origin of typefounding is obscure, and it is impossible to say who was the first to cast lead types. It is certain, however, that the long labour entailed in the multiplication of wooden types early led to their general disuse in favour of types cast from wooden models.

Early Typefounders. After the moulding of metal types was adopted, the original, or mother types, were never used for printing, but carefully preserved for moulding purposes. Nurnberg became famous in the sixteenth century for the fine metal punches it supplied to the typefounders of Europe. It was the introduction of the metal punch which gave the final stroke of separation between the trades of typefounding and printing. By this, the mother type became a die on the end of a metal rod, or bar, and the forging and cutting of these lay outside the province of the mere printer.

During the sixteenth century, the separation of the two trades slowly widened, and typefounding became a business in Mayence, Frankfort, Cologne, and other towns in Germany, and Haarlem, Leyden, and Antwerp, in Holland. Italian typefounders, following in the tradition of Aldus Manutius, early became celebrated for the excellence of their productions. Caxton brought his type from Holland to England, and for nearly three centuries the printers of this country were mostly indebted to continental typefounders for type. In 1720, Mr. William Caslon, an engraver of ornamental devices, set up as a typefounder in London, and produced work of such excellence as not only put an end to the importation of type from Europe, but also brought about an export trade in type from England to the Continent [49]. John Baskerville was the next great English typefounder. A Worcestershire man, he was at one time a writing master, in Birmingham, and there, in 1750, set up business as a typefounder. His type has never been surpassed for correct form and clearness. Later typefounde s were hardly so much pioneers as manufacturers, and their names belong rather to trade than to history.

Features of a Type. As we go forward in our study, the various processes brought into being by the powers described will come under notice; at present, we begin at the beginning. A printer uses type, and a typefounder casts type; therefore, these workmen look at the same thing with different eyes, and from opposite standpoints. A type is a small bar of lead, alloyed with other metals, the diameter of a shilling high, the size of the letter deep, and of a width prescribed by the style of the fount. The height and depth of every letter in a fount must be exactly the same.

Small as it may be, a type has many features [48]. The surface of the letter is the face, the slanting sides of the letter are the beard; the spaces at top and bottom are the shoulders, such letters as h, k, l, or d, having shoulders only at the bottom, and g, j, p, y, being shouldered at the top; the notches across the middle of the body of the letter are the nicks; the bars formed by a rut across the centre of the end of the letter are named the feet.

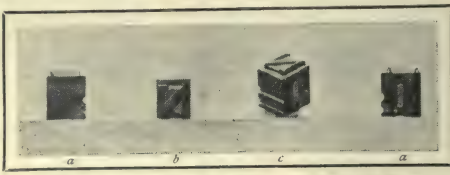
Typefounding by Hand. Typefounding long remained a handicraft, even while machinery was taking possession of many trades. The process is elaborate, and at the present day it is divided up into several operations, which may or may not be performed by one workman, or set of workers, according to the size of the foundry and the nature of the business. If most of the work is done by machinery, and only special and small founts made by hand, then one or two workmen, of high skill, with one or two assistants, will perform all the operations; but in other and more common circumstances every operation is done by a different person or set of persons. The main operations are punch-cutting, matrix-making, mould-making, mould-setting, casting, breaking off, rubbing, dressing, picking, finishing and paging.

It is a tradition among the punch-cutters that no tool save the graver was used by the great craftsmen in olden times. Very p ssibly some skilled workmen can do the work with that tool even to-day, but it is a waste of skill. The simpler and easier way is to coat the face of the punch with wax, transfer the drawing of the letter on to it, and then trace the outlines with a dry-point needle. Melt off the wax, and a clear outline remains on the face of the punch. By delicate cutting the metal round the letter is cut away, and finely shaded off to beard and shoulder [50]. No margin of error, in any detail, is allowed the cutter of letter punches; every line must be true to the fraction of a hairbreadth. To try our punch, we smoke it, and print the blackened face on a piece of proof paper. If exactly to size, and a perfect copy of the design, it is ready. So, letter by letter, sign by sign, the punches of the typefoundry are cut.

Matrix and Mould Making. An ordinary matrix is made out of a piece of copper, one inch and a quarter long, one-eighth of an inch thick, and of a width proportioned to the width of the type. Into this piece of copper the punch is struck, leaving the letter deeply embossed on the copper [50]. After being struck, the matrix, as the copper is now called, is carefully milled, in preparation for being justified to the mould. Justification is bringing the matrix into exact relation with the mould of the type body, so that all the letters when placed together will form one straight line. Practice alone enables a workman to become expert at justifying. The deviation of one-thousandth part of an inch from the proper point, in a few letters, would produce a fount of type such as even the ordinary reader would regard as a joke.

The mould of the body of the type is composed of steel, and in two parts, encased in hard wood [52]. In the making of these little steel boxes, fine skill is required; for the difference in breadth between one letter and another is often almost infinitesimal, and yet it must be obtained. This, however, is a mere matter of workmanship which can only be acquired in practice. Even the smallest mould must be absolutely true in every particular.

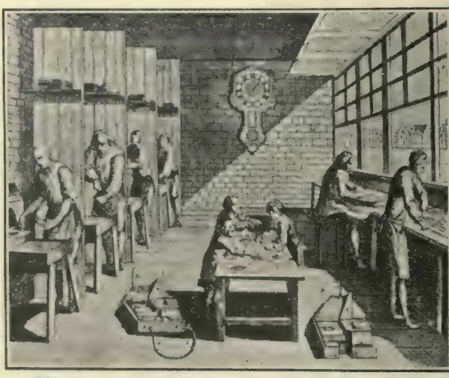
Having got our matrix and mould, our next duty is to put them together for work. If the matrix has been properly justified and the mould well made, this should not be a matter of any difficulty. The two parts of the mould are firmly clamped together, and set in position for the casting.



48. FEATURES OF A TYPE (*a*) Body (*b*) Face (*c*) Nicks and Beard (H. W. Caslon & Co., Ltd.)

Composition of the Metal. Almost every typefounder has his own favourite recipe for compounding the metal of the type he casts. Lead, regulus of antimony, and tin are the chief constituents of type metal. Lead moulds easily and cools quickly; antimony gives hardness to the lead; tin adds tenacity and toughness to the composition. Lead is cheap; tin and antimony are costly; but the smallest proportion of antimony in small type is one to three of lead. A good, hard type is made of two parts lead to one of tin and one of antimony. Other metals are also used; there are no limits to the variety of metals which may be used, so long as the metals will combine, form a strong type, and be cheap enough to compete on the market. We can prescribe no set formula; the matter is one of experiment and practice.

Casting the Type. Whatever composition we may elect to use, the metal must be kept constantly molten over a fire or gas, with a ladle in readiness. The mould being set and closed, the caster pours the molten metal from the ladle through the orifice in the top of the mould. Some casters give the mould a slight jerk, to make the metal sink down completely; but it may only be a habit; the metal fills the mould by its own weight. Almost instantly it solidifies, and the mould is opened, to cast out the newly-cast type. At the end of the type, when it is thrown from the mould, is a tag of lead, named the jet, which must be removed before any further steps are taken. Breaking off is usually done by a boy; it is a simple but necessary detail of the process, and must be neatly done. Hand-made type can be distinguished from machine-made by the size of the mark left by the tag, or jet.



49. CASLON LETTER FOUNDRY ABOUT 1740

Though a mould may be very finely adjusted, and the metal most intimately amalgamated, some slight roughness always appears on a casting. Removal of the rough skin is accomplished in a very primitive way. A boy rubs the type, letter by letter, on a flat stone, polishing the metal smooth and even.

Dressing and Picking. From the rubbing table the type comes into the hands of the dresser. This is a very important part of the typefounder's work. Setting up the letters in long lines, the dresser ranges, dresses, and clears the type, taking away any little defect or roughness which may be upon the letters. The face is his special care; but to the beard, the shoulders and the nicks he also pays keen attention. As the type comes from the dresser, it is picked, as the word goes. "Picking" is rather a bad name for the work, because it applies to the rejection of the defective letter. The picker must have a good eye for form, and know type thoroughly, for type can have a good many faults invisible to the careless or untrained eye. It may be out of range, too high, too low, clogged, or otherwise below the standard of excellence required. For any one of these defects, the letter is picked out and thrown among the scrap metal to be melted over again. With plain type, the picker merely needs to be ordinarily careful; but in working over italics and fancy types his difficulties are not small.

Before being passed on to the pagers, the type is given a final dressing. It is again inspected carefully under a magnifying glass. Letters found defective under this last scrutiny are rejected, or put aside for remedy. Then the type is set up into solid squares, called typefounders' pages, and firmly tied. It is now ready for use.

Founts of Type. In a former part of this course, the varieties, classes, sizes, and qualities of type have been exhaustively studied [see pages 5027 and 5157]. But there is one matter, peculiarly interesting to the typefounder, which could not be touched upon elsewhere. We know that a fount is made up of those letters, characters, and signs which are necessary for printing any written form of speech. But the relative numbers of each one of those letters which may be required needs to be determined, in an approximate way, at least, before the typefounder can get to work.

A variety of rules have been recommended as governing the making of what is technically named the "bill" of type; but not one has been found to answer satisfactorily. The reason for this lies in the wonderful copiousness of the English language. One writer runs on vowel sounds, and another delights in consonants. Dickens, for example, caused a run on e's in the office where a novel of his was being set up; Matthew Arnold and Oliver Wendell Holmes, widely separated in many respects, are alike in using large proportions of consonants. Striking a fair average,

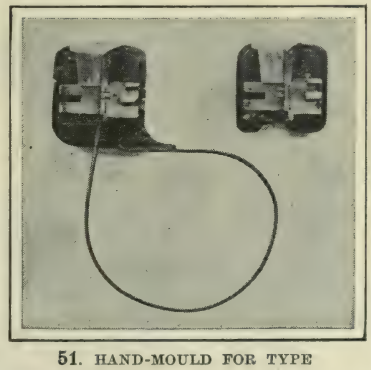
we think the "bill" given here answers very well:

a	8,500	h	6,400	o	8,000	v	1,200
b	1,600	i	8,000	p	1,700	w	2,000
c	3,000	j	400	q	500	x	400
d	4,400	k	800	r	6,200	y	2,000
e	12,000	l	4,000	s	8,000	z	200
f	2,500	m	3,000	t	9,000		
g	1,700	n	8,000	u	3,400		

Typefounding by Machinery. The first attempts at introducing machinery into the type-foundry were directed to the casting. About 1848, Messrs. Miller and Richard, of Edinburgh, patented a casting machine, which was driven by manual power. Simple in structure, being little more than the mechanical connection of the mould and the metal-pot, this machine produced good quality type at a high rate of speed. Though still used in small foundries, the hand-driven machine has been quite superseded by later inventions arranged for power drive. The first of these, patented in the year 1860, was produced by the same firm, and the machine, as it now stands, is a very efficient and handy tool. During the later years of the nineteenth century, inventors, both in Great Britain and America, were busily engaged in contriving improved type-casting machines.

50. HAND TYPEFOUNDING (*a*) Steel Punch (*b*) Copper Strike (*c*) Finished Matrix (H. W. Caslon & Co., Ltd.)

Type-casting Machine. In this machine, the two parts of the caster's equipment, the melting-pot and the mould, are brought together and placed under the government of a single mechanism. Beginning with our raw material, we find it in a pot, kept heated by a small furnace underneath, both being enclosed in a casing of cast iron. Within the pot, and communicating with a narrow channel in its side ended by a sharp nipple, is a forcing pump. At the end of the pump chamber, immersed in the liquid metal, is a valve which alternates in movement with the piston. As the piston ascends, the valve opens, and when the piston descends, the valve shuts. Through the open valve the mass of metal rushes into the pump. The valve then closes and shuts it in. With a quick movement the piston descends and drives against the metal. Having only the narrow channel terminated by the projecting nipple as an outlet, the metal is driven up the channel and out by the nipple in a strong jet. The old typefounders perfected the hand mould, and it has gone into typefounding machines modified in such particulars as mechanical exigencies demand. The mould is opened and shut by cam-actuated arms.


51. HAND-MOULD FOR TYPE

All the parts of the type-casting machine work beautifully together. When the machine starts the piston of the forcing pump in the metal-pot comes up, and the metal fills the chamber through the opened valve. Next the two arms which hold the halves of the mould come together; the mould closes. Then the arms move towards the nipple, while, at the same time, the piston goes down in the pump and drives the lead spouting up through the nipple, just at the moment the mould is brought up to it. Nipple and mould orifice join to form one channel, and the lead rushes into the mould. With the next turn of the wheel the arms part; the mould, borne round, drops the type on to a channel leading to a receptacle beside the table, into which it falls. The whole movement begins again. So, letter after letter, the type is cast.

Instead of the hand rubbing and dressing, we have a machine which rubs and dresses the type. It is rather out of favour now, because the newest casting machines produce type which needs very little dressing. Adjusted to the size of the type, the machine cuts off the jet, forms the feet, trims the front and back, and rubs the sides, by successive acts, very ingeniously arranged.

Automatic Type-casting Machines. It is in the simple form of type-casting machine which the principles of typefounding can be most easily studied and we have, on that account, examined them in detail. For the finer classes of type, and particularly for the ornamental types, the old machines hold their own. As with other industries, however, the object of machine invention has been to make the operations of production as nearly automatic as possible, and that object has been largely attained. Most typefounding establishments have special machines of their own, carefully protected by patents. One or two machines of the automatic variety have become the common property of the trade, or may be secured by anyone who cares to acquire them.

Manufacture of Wooden Type. While it is agreed that metal is the proper material for small type, there is considerable diversity of opinion as to the size at which metal ceases to be more suitable than wood. Many practical men consider that metal type larger than 6-line pica is not so useful as wood type. Founts of metal type, however, as large as 24-line, are frequently used. Of course, these are not cast solid, but made with feet at top and bottom, and a centre bar. This removes partly one serious objection to the use of metal for large type—the weight. Into the controversy we need not enter. The obvious duty of the maker of wooden type is to minimise as far as possible the objections to his product by selecting well-seasoned wood, of fine grain and hard quality, so that warping, softness, and shrinking may be reduced to the lowest possible proportions. With these precautions, wood type can be made superior in usefulness to metal type of sizes above 8-line pica, or even smaller.

Materials and Tools. The maker of wood type is practically a wood-carver, and this department differs altogether in both tools and general aspect from the type foundry. Most of the common wood-working tools are here. Circular saws, rip saws, band saws, planers, lathes, and others of the smaller machines of the wood worker are useful to the wood-type maker. With these he reduces the blocks of wood to size for putting the face on. The principal hand tools are chisels, gouges, scoopers, scrapers. Several sizes of these tools are required. The wood must be tough and hard, well-seasoned and free from knots. Many of the rarer kinds of hard woods are very suitable, but they are too costly; we therefore depend mostly on pear wood, rock maple, and box. If seasoned thoroughly, these woods produce good type.

Being a skilled handicraft, the operation of cutting type by hand can hardly be learned by mere theoretical study. Training of eye and hand in the use of the tools and the working of the wood, practice in draughtsmanship, are the only methods by which any lad can become a skilled maker of wood type. The actual steps in the operation are few and simple, calling for no stretch of the memory. Having cut the wood to size, the letter is drawn on the face of the wood, and lined out with the graver—a prism-shaped tool, with sharp edges, and held firmly between finger and thumb. The letter clearly defined, the rough of the wood about it is cut away. Before finishing, the letter should be proofed. If this seems satisfactory, the edges are finely sharpened and the margins deepened. Then the surface is well oiled and polished.

Machine Cutting of Wood Type. About the middle of the nineteenth century an ingenious wood-carver invented a carving machine which has since been found applicable to the cutting of wood type. The principle of the machine is very simple. An iron casting of each letter is made. The casting is laid in the centre of the machine. On a long spindle fixed above the bench, and controlled by the drive, sharp cutters are placed, at regular distances, with the points all level and just type-high when at rest. In the middle of the machine is a blunt tool, or stylus, and under it the iron letter is laid. When the machine is set going, the blunt stylus moves over the lines of the cast iron letter; the sharp tools, being set on the same spindle, must move in precisely the same way, and at the same depths as the blunt tool. Under the sharp tools the blocks of wood are laid, and in consequence, they are cut out in the shape of the letter. Various ways of utilising this idea have been devised; but the machines, however different in form, are similar in principle. It must be obvious that if the casting is true and properly set the wood type cut by this method must be perfectly exact. Every machine is adjustable, and may be used to produce simultaneously as many letters at a time as may be required.

Fount of Wood Type. Even in posters the characteristic determination of the English language towards the more frequent use of certain letters than others is strongly manifest, and in the make-up of letter founts, serious account of it must be taken. Several attempts have been made to bring the proper method into a short formula, but none have succeeded. The difficulty can be best illustrated by concrete examples of founts found to be useful in actual practice. For a considerable period it was usual to judge founts by the number of "E's" contained in it, and denominate them as three-E, five-E, and so on; but the better practice is to take the number of pieces in the fount for the purpose of classification—four-dozen, five-dozen, six-dozen, and on up the scale. Leaving out the points and signs, the proportions are as follow:

Five-and-a-half Dozen Fount

a	b	c	d	e	f	g	h	i	j	k	l	m	n
3	2	2	2	4	2	2	2	3	2	2	3	2	3
o	p	q	r	s	t	u	v	w	x	y	z		
3	2	1	3	3	3	2	2	2	2	1	2		

Eight-dozen Fount

a	b	c	d	e	f	g	h	i	j	k	l	m	n
4	3	3	3	5	3	3	3	4	2	2	4	3	4
o	p	q	r	s	t	u	v	w	x	y	z		
4	3	2	4	4	4	3	3	3	2	3	1		

Twelve-dozen Fount

a	b	c	d	e	f	g	h	i	j	k	l	m	n
7	5	5	5	8	5	5	5	7	3	3	6	5	6
o	p	q	r	s	t	u	v	w	x	y	z		
7	5	2	6	6	6	5	5	4	2	5	2		

Attempts have been made to get a finer surface on large type than wood affords. Some very fine founts have been made by forming the surface of the type of metal, and pinning it on to wood; but these founts do not last very well. A more recent experiment has been made with celluloid. From many points of view, this material would seem to be ideal for the making of large type. It is light, strong, tough, and may be moulded like any metal. Alternatively, celluloid may be softened, stamped, and then hardened.

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Continued

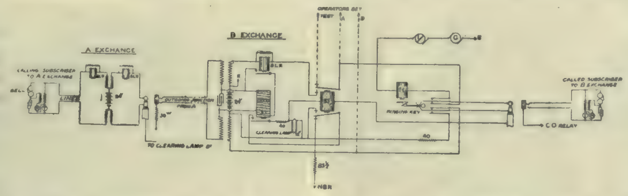
JUNCTION TELEPHONE WORK

"A" and "B" Positions. Lay-out of Exchange. How Wires in Cables are Identified by Colours. Distribution Frames. Testing

Continued from page 5881

By D. H. KENNEDY

BEFORE proceeding to describe in detail the junction apparatus a little enlargement on the subject of "A" and "B" positions may be desirable. Let us suppose an area divided into four quarters—north, south, east and west—in each of which there is an exchange of 10,000 subscribers called after its district. If the traffic is evenly divided, it is clear that 75 per cent. of the calls will pass through two exchanges, while only 25 per cent. will be completed on the same exchange as originated. To enable this interexchange traffic to be disposed of easily and quickly two sets of junctions are provided between every pair of exchanges, one for the traffic in each direction. If each "A" operator at, say, the North exchange attends to 100 subscribers, there will be 100 "A" positions. Each of these "A" operators will have access to the "outgoing junctions" to the South, East, and West exchanges. In the same way, these three exchanges have sets of junctions which are "outgoing" at their end and "incoming" at North, where they terminate on "B" positions as already described. The "B" operator at South who attends to the North "incoming junctions" listens on a call wire which is multiplied over all the "A" positions at North, and she deals only with calls from South to North. Calls in the other direction are dealt with by South "A" and North "B" operators, so that we have arrangements similar to the "up" and "down" of the railway line.



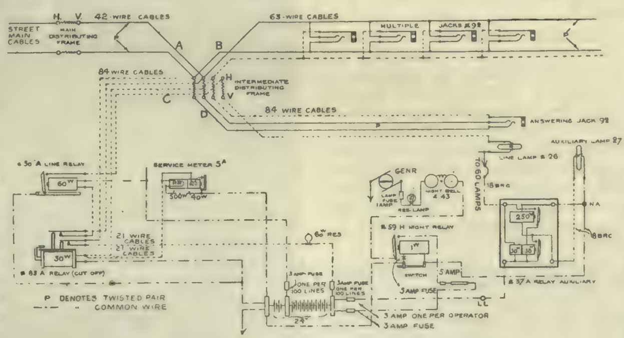
21. ARRANGEMENT FOR CONNECTING TWO SUBSCRIBERS THROUGH TWO EXCHANGES

Junction Apparatus. Figure 21 shows in a skeleton form the arrangements for connecting two subscribers through two exchanges. It will be found that the control of the communication is in the hands of the "A" operator, and that the signal from the "B" subscriber passes through to the "A" operator, so that no signal is received at "B" until "A" clears. Only the repeating coils, supervisory lamp relays, and the calling plug are shown at A.

The "A" end of the junction consists of a series of multiple jacks—only one of which is shown. At the "B" or "incoming end" there is a repeating coil having four windings, each of 20 ohms resistance. A two-microfarad condenser is connected to one side and a 24-volt battery to the other. There is also a relay having two windings, one of 12,000 ohms and one of 30 ohms; a supervisory relay and clearing lamp with 40-ohm shunt; a cut-off relay, and a combined ringing and listening key. The springs of the listening key are not shown in the diagram. The ringing key has an electromagnet with a clutch so that when actuated it continues to ring the subscriber until the closing of the circuit causes an increase of the current passing through M, so that it attracts its armature and releases the clutch.

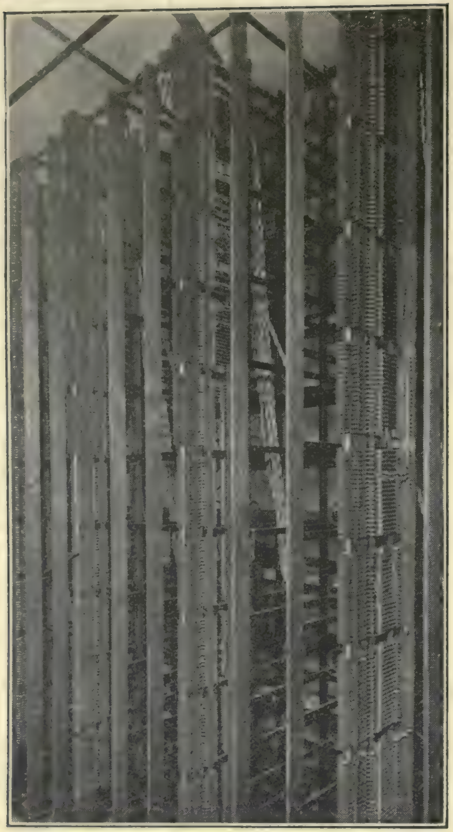
The order of events is as follows: After the "A" operator has spoken on the call wire and the "B" operator has named the junction, the "A" operator plugs in. The current from the "A" battery actuates the 12,000-ohm relay and the lamp at "B" will light, the current passing through the lamp, 40-ohm resistance, armature of 12,000 ohms relay, armature of cut-off relay, 83½-ohms resistance coil, and to earth at N.B.R.

The lamp in the calling cord at "A" will light because the current flowing is not sufficient to energise S.L.R., and the circuit of the lamp is completed through the 30-ohm resistance at the bush of the jack. The "B" operator tests and plugs into the "B" subscriber. Immediately the cut-off relay is energised and its armatures close, thus putting out the lamp, which is now shunted by the 40-ohm resistance.



22. WIRING OF A SUBSCRIBER'S CIRCUIT

The depression of the ringing key sends out an interrupted ringing current, G being the generator and I the interrupter. When the subscriber replies, the substitution of his transmitter for the condenser allows the current to energise M and thus disconnect the generator. This also provides



23. MAIN DISTRIBUTING FRAME

a path for the current from the 24-volt battery, so that S.L.R. is actuated, bringing the 30-ohm coil into parallel with the 12,000 ohms. The current from "A" now increases so that S.L.R. at "A" is energised, and the lamp in the calling-cord darkens, intimating to the "A" operator that the "B" subscriber has attended.

The Clear Signal. When the "B" subscriber replaces his receiver, the armature of S.L.R. at "B" falls back, and this in turn affects the supervisory lamp relay at "A." If a similar signal is received from the "A" subscriber, the "A" operator "meters" the call and takes down the plugs. Withdrawal of the plug from the "A" end of the junction de-energises the 12,000-ohm relay, and its armature drops back, removing the shunt from the lamp, which lights, giving the clear signal to the "B" operator, who completes the transaction by taking down the plug.

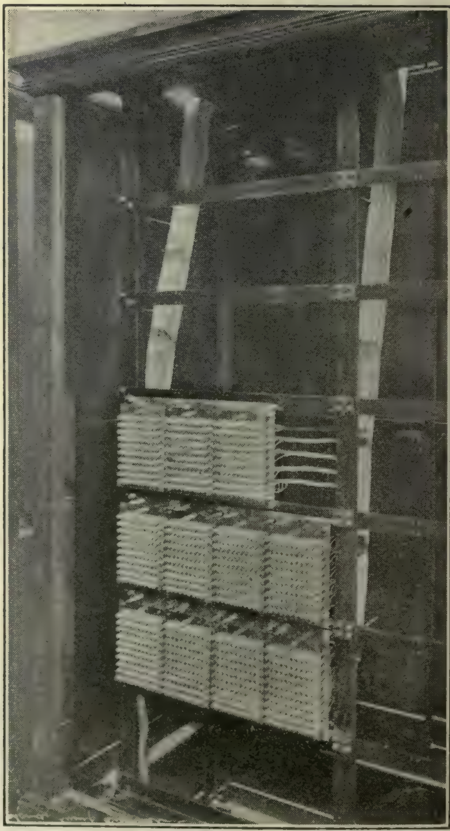
General Lay-out of Common Battery Exchange. Having considered the circuits in detail we must now take them in the mass, and consider the disposal of their various parts in a well-arrang d exchange.

The photographs illustrating this article refer to the Ealing Exchange—one of the numerous installations carried out for the Post Office by the Western Electric Company. It is designed for a maximum capacity of 5,400 subscribers, and is at present equipped for 1,080, with six "A" positions and three "B" positions. Its comparatively small size enables some of the component parts to be brought into closer proximity than would be possible in a larger exchange.

In 22 we have a diagram of the wiring of a subscriber's circuit which should be compared with 12 [page 5878]. This general system is followed in all common battery exchanges, the sizes of the various frames and the number of cables being increased in proportion to the number of subscribers.

The horizontal side of the intermediate distribution frame may be regarded as the centre of the wiring system from which radiate four principal cable runs: A, the wires to the main distribution frame, going out to the lines, arranged in 42-wire cables (each cable contains 21 twisted pairs for 20 subscribers, and 1 spare pair); B, the wires to the multiple jacks in 63-wire cables (20 subscribers, 1 spare); C, the wires to the relay racks in 84-wire cables (20 subscribers, 1 spare); and D, the wires to the answering, or A positions, also in 84-wire cables. The tags on the intermediate distribution frame may be read from left to right as "tip, ring, test, lamp."

Cable Colour Code. The cables contain wires of No. 22 copper, and, except in the case of the 21-wires, are flat in section. Identification of any wire at any point is made possible by using

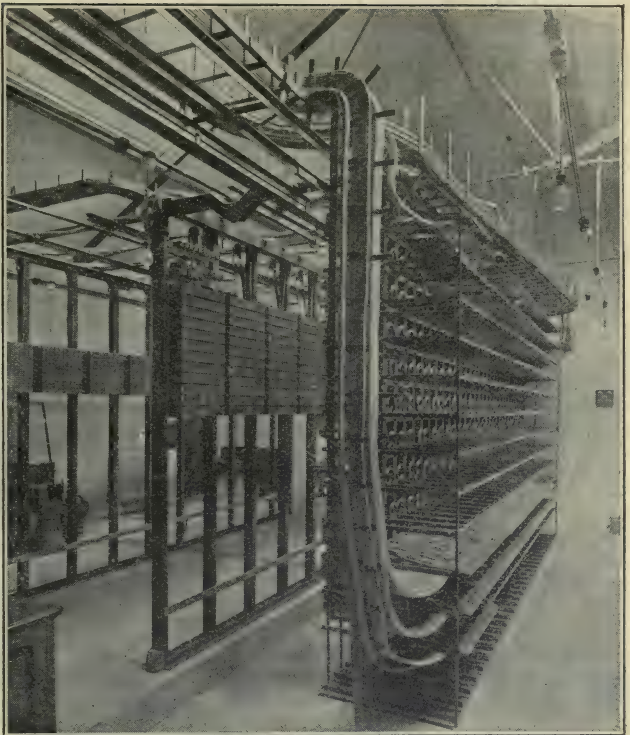


24. CORNER OF RESISTANCE LAMP CABINET

distinctively coloured cottons and following a definite colour code. It is made up as follows:

1 Blue	12 Orange-green
2 Orange	13 Orange-brown
3 Green	14 Orange-slate
4 Brown	15 Green-white
5 Slate	16 Green-brown
6 Blue-white	17 Green-slate
7 Blue-orange	18 Brown-white
8 Blue-green	19 Brown-slate
9 Blue-brown	20 Slate-white
10 Blue-slate	21 The spare wire is red.
11 Orange-white	

This code gives us the colours and numbers for a 21-wire cable. In a 42-wire cable each code wire is twisted with a white wire. In a 63-wire cable we have, in addition to the 42 already described, 21 wires coloured (1) red-blue, (2) red-orange, etc., the colour code being repeated, but with the addition of red on each wire, the spare wire being red-white. In an 84-wire cable the red-blue series are each twisted with solid red wires.



25. INTERMEDIATE FRAME

Main Distributing Frame. The main distributing frame [23], or M.D.F. as it is usually called, is the connecting point between the street distribution main cables and the internal exchange wiring. It is built up of open iron framework. The main cable in which the subscribers' wires approach the exchange are of the paper - insulated, lead - covered type, but at the point of entry to the building they are provided with a short termination length of cable, the conductors of which are insulated with wrappings of silk and cotton. The silk and cotton cable is brought to the main distributing frame, where it is fanned out like a comb, beeswaxed, and laced with twine, the wires being arranged at distances suitable for the tags. The cable is then fastened up *under* one of the horizontal runs and the wire soldered to the tags. The horizontal side of the main distributing frame is not visible in 23, but a glance at the horizontal side of the intermediate frame, shown in 25, will sufficiently explain. The vertical side of the main distributing frame [23], as well as providing the terminating point for the exchange wiring, provides accommodation for the protective devices. These are of three kinds—namely, tubular fuses, heat coils, and carbon lightning protectors. The springs which hold the heat coils also serve as test jacks. Connection may be made from any wire on the horizontal side to any exchange number on the vertical side, and this is done by means of a two-wire jumper of flame-proof insulation. It is first soldered to the tags on the vertical side, then passed up or down vertically until opposite the horizontal line to which the street wire is connected. The jumper is then passed through the large iron eye, and along the top of the horizontal run to the tags to which it is soldered.

Intermediate Distributing Frame. In 25, on the right side, there is a view of the intermediate distributing frame, the ironwork details being very simliar to those of the main distributing frame. At the near end can be seen the 42-wire cables arriving from the main distributing frame, while at the further end they are going on by means of another iron runway to the switch-room, and to the relay rack. The vertical side of the intermediate distributing frame is provided with strips of tags of the same kind as on the horizontal side. For this frame four wire jumpers are necessary, and, as clearly indicated by 22, it affects only the answering position, enabling any line number to be connected to any given position number. The sole object of providing this frame is to allow of the adjustment of the load on the various "A" positions. With a view to facilitating this proceeding, a special meter is provided for each position, so that in metering a subscriber's call the operator also counts one on her "position meter." By observing these from time to time the exchange manager is able to watch the variation of the loads on positions, and any over-pressed or under-pressed position can be levelled up or down by suitable crossing on the intermediate distributing frame.

Relay and Meter Frames. To the left of the intermediate distributing frame [24] is the relay frame; line and cut-off relays are built up together, and these again in sets of ten, so that the top left-hand strip contains, as indicated by the figures on it, the line and cut-off relays for numbers 0 to 9. Of course, 0 is always appropriated for service purposes.

Still further to the left is the meter frame. These also are built up on strips containing 10. Each has, however, a separate cover with a mica window through which the reading can be taken. At the bottom of each frame there is a stout flat bar of copper, which serves as the common earth return

indicated in 22 by the dot-and-dash lines from the meter and cut-off relays respectively.

In the case of the meter frame, the heavy cable connecting with the copper bar can be seen entering the floor troughing on its way to the positive pole of the battery.

This illustration gives a good idea of the neat way in which cables are carried from point to point by means of open ironwork runs. As the subscribers increase, apparatus will be added from time to time until the limit of the equipment has been reached, by which time these will be quite filled.

Resistance Lamp Cabinet. The 60-ohm resistance lamps are arranged in blocks of 100, and 24 shows a corner of the cabinet equipped for the first 1,100. An earth fault on a subscriber's "B" or "ring" line will at once show up here. Above each group of 100 there is a special comparison lamp which can be joined across the battery by a key (not shown), so that the glow due to the full battery power can be compared with that showing on lamp.

Condenser and Repeating Coil Rack. Another iron framework, visible under the clock in 26, is provided as a resting place for the condensers used in connection with the junction circuits, as well as for the repeating coils used in all the coil circuits. Reference to 11 [page 5878] will recall the fact that the repeating coils are joined directly to the battery. It is necessary, therefore, that fuses should be introduced in order to avert fire danger. For this purpose the cabinet on the left of the coil rack is provided and equipped with a slate base and copper busbars and terminals on which the fuses are mounted.

In order to lessen the time of interruption when a fuse is blown, an ingenious alarm system is introduced. Each fuse is provided with a white glass bead. When a fuse blows, this is thrown outwards. Simultaneously, a lamp at the end of the busbar lights, and the bell on the side of the cabinet rings loudly. This calls the attendant, the glowing lamp indicates the busbar, and the glass bead indicates the blown fuse, which is thus localised and replaced very quickly.

Testing. In 26 we are enabled to see the wiring of the relays, and beyond them the vertical side of the intermediate distributing frame. The neat way in which the 84-wire cables are fanned out, each to 10 line and cut-off relays, is conspicuous, and comparison with 22 should again be made. All testing of circuits is done from the desk, fixed in this case midway between the relay rack and the fuse cabinet. It is fully equipped for two testing officers. In America they are called "wire chiefs," but, except in connection with the desk, the title has not taken root in this country.

Built into the face of the desk on each side is a voltmeter of the D'Arsonval type, which is the sole testing instrument for each officer. The resistance of the instrument can be made at will 100,000 ohms, 10,000 ohms, or 1,000 ohms. An E.M.F. of 40 volts is provided by dry cells. When any resistance is to be measured, it is joined in series with the voltmeter and battery, and the required value is given by the formula $R = V\left(\frac{D^1}{D} - 1\right)$ where R = unknown resistance, V = voltmeter resistance, D = deflection of voltmeter when terminals are joined direct to 40 volts, and D^1 = deflection given when unknown resistance is included in circuit. Rough capacity tests can also be made. Cards giving the readings corresponding to various deflections are provided.

26. CONDENSER AND REPEATING COIL RACK

When a new subscriber is being connected up, his line is tested for insulation and conductivity, and the results carefully recorded for comparison with tests to be made subsequently when periodical maintenance visits are made by the linemen. These are most valuable for enabling faults to come under notice in time to avert serious trouble.

Special Connecting-up Switch. Another interesting and useful item to be found near the M.D.F. is a small switch fitted with lamps, jacks, and pegs and cords, and arranged so as to facilitate communication between the test-room and linemen who are engaged connecting up new subscribers. The wires appropriated for the new subscribers are connected to a jack on this switch, and the linemen or jointer who is at work on them can at any time obtain the attention of the test-room in order that any test he requires may be made.

Continued

MAKING & MENDING A WATCH

The Watchmaker's Tools. Dissecting a Watch. The Parts of a Watch. Watch Repairs. Cylinder and Horizontal Watches

Continued from page 5894

By JOHN P. LORD

THE tools used by watchmakers are those which they also require for the clockwork which comes into their hands, but, in addition, they require a number of very small screwdrivers, which are made on quite a different plan to the ordinary tool with which we are all accustomed. The most practical screwdrivers can be made by the workman himself.

A complete range of screwdrivers runs from $\frac{1}{8}$ in. in width down to $\frac{1}{64}$ in., the last-named being used for removing jewel screws.

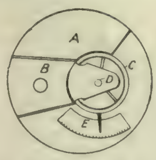
The eyeglass, which is generally considered indispensable to the watchmaker, can well be dispensed with if the workman has good eyes, and if he has not, a pair of spectacles will benefit him, and save him from damaging his sight. Occasionally the use of a glass is convenient in order to see any dirt in a watch, and then it should be fixed in the eye as follows:

The edge of the glass should not be less than 1 in. in diameter, and should not exceed 2 in. Press the upper edge under a fold of skin just *above* the eyebrow, unless you have very projecting bones, when you may be able to catch it beneath the rim of the bone. Gently press the lower rim against the skin of the cheek, when the glass will grip and be easily held. Anything like making grimaces is quite unnecessary, and will prevent you from seeing. In purchasing a glass do not get one too strong.

Several brushes, rather finer than those used for clockwork, will be required, and a piece of billiard chalk or French chalk to clean them on. Tissue-paper, pegs of wood, tweezers, nippers like cutting pliers, and so forth, will be necessary.

As dust is the chief enemy of watches, a plentiful supply of broken wineglasses should be collected, for they are always useful to use as small bell-glasses.

Taking a Watch to Pieces. Though we have not followed the regular practice in making a start at clockwork, we will do so in learning the parts of a watch, for two reasons—namely, the works of an English lever watch are very similar to those of our cheap clock on a smaller scale, and levers are expensive and easily damaged. The old verge watch will show us some new features, is strong, and an old one can be borrowed from most obliging watchmakers. Further, the mechanism of a verge watch will, apart from the escapement, teach us the essentials of the mechanism of the old stye of lever watch, and even that of the chronometer.



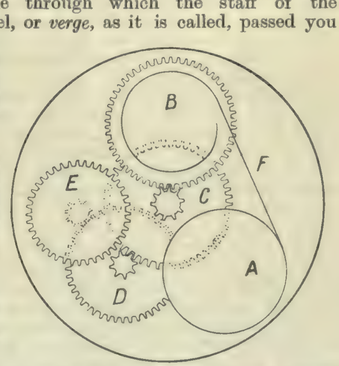
6. TOP PLATE OF VERGE WATCH
A. Name-plate *B.* Cock *C.* Balance wheel *D.* Pivot of balance *E* Regulator

To take a watch out of its case you must look for the fastening, which, in a verge watch, are a spring and hinge. The hinge is under the XII., and the spring under the VI. Press out the pin of the hinge first with the points of the tweezers, remembering that the pins of a watch are always put in in the direction from the III. to the IX., so must be pushed out in the opposite direction. If the spring be then lifted the entire movement will come out into the hand.

The next thing to do before examining the works is to remove the hands, and this is easily done, either with a pair of cutting pliers, just catching the edges under the centre flanges, or by prising up with the edge of a knife. Once the hands are removed, we can look at the works. Turn them over, and lay the watch on the rim of the eyeglass, or on the edge of a small wineglass, to prevent anything being damaged.

The first thing that strikes us is that the balance, instead of being inside the watch, as in the cheap clock, is held by a cock on the outside back-plate. Beyond that we see a curved plate, which is called the *name-plate,* and which covers the spring barrel, and that is all to be seen. The figure will explain these parts. Look under the dial, and see where the pins are that hold it on, and then prise these out by lightly cutting into them with the edge of your knife, and then turning outwards. The dial can then be removed, and the motion work exposed, which is the same as in our cheap clock, so we need not trouble about it. One thing, however, we must impress upon you here—never take hold of watch parts in your hands; always use the tweezers or a piece of tissue-paper.

Removing the Plates. Clear off the motion work, with the exception of the cannon pinion, and then turn the watch over, and you will be ready to take off the plates. First unscrew the screws which hold the cock, and gently lift it. Next unpin the balance spring and withdraw the balance straight upwards, checking one of the wheels at the side, so as not to let the watch run down too violently. Round the place where the balance lay will be found the regulator, which may be a plain circle, or possibly very highly decorated. At the hole through which the staff of the balance wheel, or *verge,* as it is called, passed you will see a little wheel with teeth standing parallel to its axis, which is horizontal as the watch lies. This species of wheel is a crown wheel, and the escapement of this watch is caused by two thin flanges, which you will see on



7. TRAIN OF VERGE WATCH, WITH TOP PLATE REMOVED
A. Barrel *B.* Fusee *C.* Central wheel *D.* Third wheel *E.* Crown wheel, or contrate *F.* Chain

the balance staff swinging from tooth to tooth, and so permitting one at a time to pass. The motion of this crown wheel is passed to a pinion on its arbor, and this is the escape pinion of this kind of watch. Unscrew the name-plate, and you will see the barrel beneath, lying with a chain coiled round it.

Before going further let the watch run down to its full extent, and then proceed to "let down the spring," which means let all the slack of the spring out. This is done as follows. On the dial side of the watch-plate will be seen a tiny ratchet and click. Put a key on the winding square and turn just enough to enable you to raise the click; then let the spring run down carefully, noting how much it has to go, so as to be able to set it up when you put the watch together again.

The spring being now quite loose, the chain will lie loose round the barrel, and the barrel may be lifted out after the tiny chain has been unhooked from the hole on it. The chain can then be released from the fusee round which it runs, and taken away and placed under cover. Note that the hooks on the ends of the chain differ, that on the fusee end being short, while that which goes into the barrel has a long tail.

All the top of the plate being clear, unpin the plate as in clockwork, and carefully lift the plate off, keeping it parallel to the bottom one, so as not to strain the pivots.

The Train. The train of wheels will then be seen, if you replace the barrel for the moment, as is illustrated. The actual motion is as follows: The spring in the barrel pulls the chain off the fusee, which is the curious wheel with the spiral step running up it, and the wheel on the fusee may be considered as the great wheel. This runs on the centre-wheel pinion, which in turn moves the third wheel. The fourth wheel, moved by this, has its teeth standing up; this is a crown wheel, and is called the *contrate wheel* in verge watches. The teeth of this work on the pinion of the escape-wheel arbor, and so the escape wheel turns. Comparison with our American clock will show us no really fundamental differences, though the mechanical means of imparting the force of the spring is strange.

It may be asked why the fusee has steps running up it. The reason is that the more a spring unwinds the weaker it gets, and the spiral is regulated to give the spring harder work to do when it is strong and easier work when it is weak, and so counteract the variation in its strength, and enable tolerably equal vibrations of the balance to be maintained.

The wheels can now be taken out, taking the barrel first, then the contrate, next the fusee, then the second wheel, and, lastly, the third wheel, which will probably have to be removed by unscrewing the plate on the pillar plate of the watch, as the second wheel in verges is often held in by its pinion, which should not be disturbed unless absolutely necessary.

The parts should all be brushed and cleaned carefully, the wheels being held the while between pieces of tissue paper. The holes must be cleaned out with pegs until the wood returns quite clean, and everything done as in clock cleaning, save that far greater care must be taken, and the minimum amount of pressure used on the delicate pinions and arbors. When all is clean we will turn over the top plate, and attached to it we shall find the escape wheel, with its pinion running between two little blocks, the inside one of which is called the *potence cock*. This potence cock not only acts as a bearing for the 'scape wheel, but also for the foot of the verge. The other end of the pinion passes into a bearing in a little plug called the *follower*, which passes through the outside stud, or counter potence, and by withdrawing this plug the 'scape wheel and its parts can be withdrawn.

You may find some difficulty in cleaning the tiny pivots of the arbors, but if you use a fragment of common elder pith instead of the brush you will find that they can be beautifully cleaned.

Examining. Having got your wheel parts thoroughly clean, the next thing to do is to examine them, and try them all by spinning them in their own pivots or between a pair of female centres in the turns to make certain that they are quite true —in flat and in round, as the watchmakers call it. If a wheel is a little out of flat a small steel bar, having a hollow in it to receive the arbor, but well able to support the wheel, is put into the vice, and the wheel is placed on this. The stake is called a "bumping up stake." With a very light hammer the wheel can now be gently tapped till it is quite flat. Wheels out of round must be discarded, and a new wheel fitted to the arbor exactly as was done in repairing a clock, but on a smaller scale. Any wheels which are loose on their collets must be carefully riveted up, and a wheel with only one tooth broken may have that repaired either by inserting a new piece, as in a clock wheel, or by soldering in a tiny fragment to form a new tooth.

Next examine the pillars in the pillar plate, and if any are loose they must be riveted tight, for a defective pillar often makes a watch stop through shifting the positions of the pivot holes.

Now begin to put up the watch, and try the depths and end shakes of the pinions, beginning with the gearing of the fusee with the centre wheel pinion. The fusee must stand quite upright in its pivot hole, or else the chain will not run on properly. If it is defective the shoulder of the pivot must be turned till it is right. The depths in these watches should be about two-thirds of the wheel teeth to make them run smoothly. Experience alone will tell you whether the amount of any particular pair of wheels should be more or less.

The Mainspring. We may now take the barrel, which contains the mainspring, and take out the spring to clean. The lid of the barrel will be readily distinguished by having a tiny groove cut in its edge to permit of the point of the tweezers being inserted to prise up the lid. When that is done the spring will be seen lying coiled up round inside the rim of the barrel. The barrel arbor must now be removed by turning the arbor the opposite way to that which winds the spring, and then, when you have heard the click, hold the spring in the barrel, and firmly pull out the barrel. Now seize the centre part of the spring with the tweezers, and carefully holding the rest in the barrel, disengage one or two rounds from the spring, and get them out of the barrel. The rest will then come out with ease, provided you release coil after coil, and do not let the whole lot rush out. When the last coil is about to come out, you must unhook the end of the spring from the rim of the barrel.

The spring can now be cleaned by passing it between the blades of the tweezers which have been covered with tissue paper. The inside of the barrel must also be cleaned with paper rolled round a piece of wood. Similarly the barrel arbor and pivot

holes should be thoroughly cleaned, and any rust removed with emery and oil, followed by crocus and oil, and lastly by the burnisher.

Replacing the mainspring in the barrel is done in the trade by means of a special winder which catches the centre end of the spring, and winds it up till it is just tight enough to go into the barrel. When placed in the barrel it is turned round till it hooks itself on the outside. But the operation can be done by hand after a very little practice. First hook on the outside end of the spring in the barrel, and then start to coil the spring carefully into the barrel, laying each coil close up to the one outside it. If the barrel is kept rotating in the left hand, with the thumb above the spring, as the right feeds in the spring, the task is not difficult, and can be performed almost as rapidly as with the winder. When all the spring is in, pass the barrel arbor through the centre and turn it till the hook catches. Then put a drop of oil on the spring, and fix on the lid of the barrel by pressing it firmly.

The Adjusting Rod. To adjust the spring of a verge watch the barrel, fusee, and centre wheel must be put into the frame and the chain attached to barrel and fusee. The barrel is now wound up till the chain is all on it. Now give the key another half turn, which will set up the spring a little. An instrument called an *adjusting rod,* which is really a long steel rod along which a weight slides, is put on the winding square, and one turn given to the fusee. The weight is now slid along the bar till it exactly counterbalances the force of the spring. Now the fusee is turned till it is full of chain, and the spring force again tested. If it is less than it was before, then the spring is set up too much; if more, then the spring must be set up a little more. When the spring is adjusted, a mark must be made on the barrel arbor and on the name-plate or top plate to enable you to set it up when required to the right point.

The chain is cleaned by wiping it with paper, and no oil must be put on it. The click work for keeping the watch going while it is being wound, which is to be found inside the fusee of the more modern verge watches, must be got at for cleaning by unpinning the great wheel from below the fusee, and pulling it off its arbor. All can then be cleaned. The potence cock must have the wedge which holds the bearing for the lower end of the verge pulled out to enable you to clean the pivot hole, which must then be oiled before replacing.

To Put Together. Lay the pillar plate on an eyeglass, and drop in the wheels in order, remembering that the third wheel is the first in this class of watch to be inserted, unless it is fastened from behind. When all are in their places except the barrel, put on the upper plate carefully, dodging the pivots into their bearings as they touch the plate, which must be lowered gradually. When all are in pin on the plate, test the wheels by giving an impulse to the great wheel, which should set the whole train in motion, then put in the barrel and chain, first fastening down the barrel with the name plate, and then hooking on the chain, which should be laid straight out in preparation. Pass the chain from the side of the fusee inside the pillar, and then to the barrel, turning the latter till the chain can be hooked in its hole. Then with a key on the square turn till the chain is nearly all wound up and is in a convenient position to be hooked to the fusee, which is then done. Then set the spring up as before.

The balance is now dropped in, the verge passing down to its bearing, and the spring being passed between the regulator guides, and thence through its stud, and secured in its proper position, after which the cock is put on and the watch should go. The motion wheels and dial are put on as indicated when removing, and the whole replaced in its case, after which it is best to put on the hands, and not before, for the cock might get bent in pressing them on.

Repairs. A broken mainspring will have to be replaced by a new one, and as this operation will frequently have to be performed in all watches which fall into the hands of the worker we shall take this operation first. Select a spring about the same width and thickness as the old one. Measure it in the barrel. It should reach nearly to the top, and should occupy one half of the space between the arbor and the edge. If it is too long cut off a piece to make it the right length. Heat an inch at the outer end in a Bunsen burner till nearly red hot, and allow to cool. Then punch a hole in it to take the hook, and taper off the point of the spring. The hole will then hook on the barrel hook, and the spring can be fitted. If, however, as is sometimes the case, the barrel has a hole, then you must rivet a hook to the end of the spring. If a spring is too strong, but otherwise of the right size, you may slightly weaken it by rubbing the inside of the coil with a piece of stick charged with emery and oil, afterwards removing all with turpentine, and drying perfectly. If the break is near the outer end the same spring can be made to answer by punching the proper hole, or by adding a hook as may be required.

To Mend a Chain. A broken chain is a very frequent accident in verge and other fusee watches, and the necessary repair is not difficult to make. Rest the broken chain on a piece of hard wood, and while pressing the last link down with the thumbnail, prize open the link rivet with the edge of a penknife. Turn the chain over and loosen the corresponding end of the opposite link in the same manner. With a little manœuvring, the broken link can now be removed, and in the open space thus made, the link of the other portion of the chain can be inserted. Then, with a piece of steel wire, tempered till it is blue, make a pin to pass through the link holes so as to fasten the chain. Press the pin in tight, and cut off close with pliers. File with a smooth file till nearly level with the chain, and then a few taps with a light, round-faced hammer will make a little rivet sufficient to hold.

Putting in a New Barrel Arbor. This is rather a delicate job, which occasionally is necessary. In making new watches, the arbors are generally purchased in the rough, and in the case of Geneva arbors with ratchets, almost invariably so, when only accurate fitting and polishing is required. But occasionally it happens that a watch is brought in for repairs, and it may be necessary to make the arbor instead of purchasing a single one.

There are three kinds of arbors in common use—namely, the plain English arbor, the plain Geneva and the Geneva with ratchet. The last you must buy, but the other two you can make. Take a piece of ordinary round steel and turn it nearly to shape in the foot lathe. Then attach a screw ferrule, and turn down in the turns till the body, or the centre part, is exactly to gauge. When polished, it should just fit the barrel holes tightly, and then one turn with a suitable sized broach in the hole will give it enough freedom.

In an English arbor, next turn the top pivot and fit it into the name plate, after which carefully file the square on the other end of the arbor to receive the ratchet.

In a Geneva arbor it is best to make the square for the finger piece of the stop work first, and then finish the lower pivot, after which the top, or winding square, must be made. This also holds the ratchet. The ends of the squares are rounded off in a screw-head tool or in a lathe. The hook for the spring in both arbors is made by drilling a hole obliquely in the body and driving in tight a piece of highly tempered steel, afterwards cutting off the excess and filing to shape.

To Put on a Balance Spring. The balance spring, which should be selected as near the size and thickness of the broken one, is to be fixed into the centre collet, where there is a split to hold it, which may require tightening up by a gentle tap with a punch. Then, seeing that the spring lies quite flat, pass it through the regulator fork and into the stud. Turn till the staff of the wheel when in the frame is in proper position, and then peg up lightly. If the spring is found to be too strong it can be weakened by very lightly rubbing the interior of the centre coil with a flattened piece of wire charged with oilstone and oil, the spring being removed from its collet for the purpose and mounted on an arbor or wooden pin. Very little suffices. If the spring is too weak, and will not work if more be taken up in the pin, then another new one must be taken.

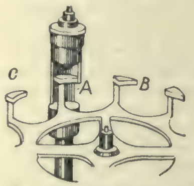
Other Repairs. Bent teeth and defective pinion leaves and faulty pivots are dealt with in exactly the same way as those of a clock, so the work which we have learned will be of service to us. Only practice can make the hands sufficiently delicate and steady to do fine watch work with precision, and the beginner will have to be prepared for long years of training.

New Watches. Contrary to the general opinion, no one makes a watch entirely himself, some dozen, at least, being employed on the rough parts alone, and a host of other trades also called in to help. For instance, the cutting of the pivot holes in the plates is one trade; the making of the jewel collars and fittings is another; the fitting of the jewels a third; and the fashioning of jewelled pivots a fourth, and so on. The watchmaker is a man who knows how to take a watch to pieces and clean it, and do the necessary repairs; but he must not be expected to make every part himself. Also, he can purchase his parts and finish them, put them together and adjust them himself. In that last word the secret of his skill stands revealed. The adjusting of a watch so that its depths and end shakes are absolutely correct, its balance and escapement working regularly, and its daily rate even, is a faculty which only practical experience can teach. No book can initiate one into that branch; all that a book can do is to give the rough, practical directions for the manual work in setting up a watch.

Other Kinds of Watches. The two main types of watches to be found on the English market are the lever watches and the cylinder or horizontal ones. Lever watches greatly resemble the clock we experimented upon. The lever notch is occasionally furnished with jewelled sides, which engage in the pin on the balance staff by which the lever, turning on its fulcrum, is swung backwards and forwards, lifting the pallets in exactly the same way as in a spring clock. They are driven by a spring coiled in a barrel, the edge of which forms the great wheel, so they have a wheel less than fusee watches. They are of various kinds, but we need not trouble about the varieties, since once the main principle is understood, the variations will be readily grasped.

Cylinder or Horizontal Watches. These, of Swiss make, used to form a very great portion of the cheap watches sold in England. They keep fair time, but unfortunately their escapements are rather delicate and readily broken. The 'scape wheel is of a pattern which we have not yet met. Round the rim a series of projections stand up at right angles to the plane of the wheel. On the tops of these, and above the plane of the wheel, are a number of teeth, the outer edge of all of which form segments of the same circle. The teeth are like wedges, with one curved side, and all point in the direction the wheel is to travel.

The staff of the balance, or verge, is expanded into a comparatively large hollow cylinder in the middle, large enough to hold one tooth of the 'scape wheel, and the stem on which it stands. Very nearly half of the side of this cylinder is cut away. Now, as the balance wheel swings one tooth passes into the cylinder, and before it can go through its point is caught on the inside face of the cylinder. The swing continues. Then it reverses, and as soon as the point of the tooth has emerged from the cylinder the slope of the outer face of the tooth rubbing against the exit lip gives an impulse to the cylinder and keeps up the swing. But, less than half a circle being cut away, the outside of the cylinder has caught the following tooth, and prevented it from entering till that swing is done and the forward one begun, when the next tooth takes up the work, enters the cylinder, and in doing so imparts an impulse by rubbing on the entering lip. The form is ingenious, and the annexed diagram may explain its action.



8. CYLINDER WATCH ESCAPEMENT
A. Cylinder swinging to left
B. Tooth just left
C. Tooth waiting to enter

Watches of this type are very often made without pillars, each wheel being held by a separate cock. This gives the watch a very open appearance, and permits of the train of wheels being examined without taking the whole watch to pieces; in taking to pieces, each cock must be removed separately. These watches, like levers, are driven by a spring, enclosed in a barrel, the arbor of which is usually a Geneva arbor with ratchet, though sometimes a plain Geneva arbor. Their works are generally small, and until the beginner has practised on a verge, he is not recommended to try his hand on a Swiss watch with the horizontal escapement.

Chronometers are special timepieces for ships, and generally possess a fusee and chain, to equalise any variation in the spring. They are extremely delicate, and have to be kept in one position. The making and adjusting of these is a trade of its own, and we need not consider it, for the chronometer maker has to be a first-class watchmaker before he can learn the rudiments of his more scientific calling.

One last word of caution: books may teach you how to do a job; only practice will enable you to do it satisfactorily.

CLOCKS AND WATCHES *concluded; followed by* SCIENTIFIC INSTRUMENTS

PLANE TRIGONOMETRY

Measurement of Angles. Rectangular and Circular Measure. Value of π. Measure of any Angle. Use of Signs + and −

Continued from page 5944

By HERBERT J. ALLPORT, M.A.

1. Measurement of Angles. The way in which the magnitude of the angle AOB is measured has been explained on page 4207. In Geometry we considered only those angles in which the revolving line has turned through less than four right angles, but in Trigonometry the revolving line may make any number of complete revolutions before coming to its final position.

In the measurement of any sort of quantity we require a *unit* of the same kind as the thing measured: the *measure* of the quantity is the *number of times* which the thing measured contains the unit. For *practical* work the unit angle is the *Right Angle.* In *theoretical* investigations it is more convenient to use for unit the angle subtended at the centre of a circle by an arc equal in length to the radius. It is, of course, necessary that the size of a unit should always be the same; hence we shall have to prove that this angle at the centre of a circle is always the same size, whether the circle be large or small.

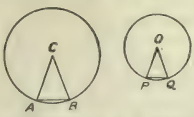
The two systems of measurement are called, from the respective units employed—

(*a*) Rectangular Measure; (*b*) Circular Measure.

2. Rectangular Measure. The right angle is a large angle, and therefore has to be subdivided. It is divided into 90 equal parts called *degrees*; a degree is divided into 60 equal parts called *minutes*; a minute is divided into 60 equal parts called *seconds*. These are indicated, respectively, by the symbols °, ′, ″, so that an angle which contains 137 degrees 47 minutes and 19 seconds would be written 137° 47′ 19″.

Note. Another method of subdivision, in which a right angle is divided into 100 *grades*, a grade into 100 *minutes*, a minute into 100 *seconds*, was suggested at the time of the French Revolution. This system, however, has never been adopted, because of the alterations which would be necessary in the records of geographical and astronomical observations.

3. Circular Measure. The unit of circular measure is called the *radian*, and is, as stated above, the angle subtended at the centre of any circle by an arc equal in length to the radius of the circle.



In order to prove that this angle is independent of the size of the circle we must first show that the ratio of the circumference to the diameter is the same for all circles.

Draw any two circles, and let their radii be r_1 and r_2. Describe a regular polygon of n sides in each circle. Let AB be a side of one polygon, and PQ a side of the other. Then, if C and O be the centres of the circles, the angles ACB and POQ are equal, since each is $\frac{1}{n}$ of four right angles. But Δs ABC, OPQ are isosceles; therefore, since their vertical $\angle$s are equal, their remaining $\angle$s are equal.

$$\because \frac{AB}{AC} = \frac{PQ}{PO}.$$

$$\therefore \frac{n \cdot AB}{r_1} = \frac{n \cdot PQ}{r_2}.$$

Now n . AB and n . PQ are the perimeters (*i.e.*, sums of the sides) of the polygons, and by making n infinitely great these perimeters differ from the circumferences of the circles by an infinitely small quantity. Hence

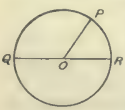
$$\frac{\text{First } \bigcirc^{ce}}{r_1} = \frac{\text{Second } \bigcirc^{ce}}{r_2}.$$

Thus, *the ratio of the* $\bigcirc^{ce}$ *to the radius, and therefore of the* $\bigcirc^{ce}$ *to the diameter, is the same for all* $\odot$s. This ratio is an incommensurable quantity [see page 1440], and is always denoted by the Greek letter π. Hence, in all circles,

Circumference = $\pi \times$ *Diameter.*

The *numerical value* of π cannot be found exactly; but by more advanced Trigonometry than we are dealing with at present its value can be found to any degree of approximation. To five decimal places the value is 3·14159. We know that $3\frac{1}{7}$ = 3·142857, so that if we use the value $3\frac{1}{7}$ for π we shall be accurate to two decimal places, and this is generally sufficient for practical purposes.

All Radians are Equal. Let PQR be a $\odot$ whose centre is O, and let the *arc* RP be equal in length to the radius. Note that it is not the *chord* RP which equals the radius.



Now, it can be proved that the ratio of angles at the centre of a $\odot$ is the same as the ratio of the arcs on which they stand.

$$\because \frac{\angle ROP}{\angle ROQ} = \frac{\text{arc RP}}{\text{arc RPQ}}$$

$$= \frac{\text{radius}}{\text{semi-}\bigcirc^{ce}} = \frac{r}{\pi r} = \frac{1}{\pi},$$

$$\textit{i.e.,}\ \frac{\text{A radian}}{2 \text{ right } \angle s} = \frac{1}{\pi};$$

$$\text{or, a radian} = \frac{1}{\pi} \text{ of } 2 \text{ right } \angle s.$$

Hence, a radian is always the same fraction of two right $\angle$s, and is therefore a constant angle.

4. Unit of Measurement. We have now shown that a radian is a constant angle, and so may be used as a unit for measuring other angles. The *number of radians* in an angle is the

circular measure of the angle. By Article 3,

$$\text{A radian} = \frac{1}{\pi} \text{ of } 180^\circ$$
$$= \frac{180^\circ}{3\cdot14159} = 57\cdot295...^\circ$$

Also, since a radian $= \frac{1}{\pi}$ of 2 right ∠s.

$$\therefore \pi \text{ radians} = 2 \text{ right } \angle\text{s};$$

i.e., the circular measure of two right ∠s is π.

NOTE. Angles expressed in circular measure are usually denoted by Greek letters, such as α, β, θ. We then speak of "the angle θ." Really, it should be "the angle θ *radians*," but the use of the Greek letter avoids all ambiguity. In the same way we speak of the "angle sixty" when we mean "sixty *degrees*." Similarly, "the angle A" always means "A *degrees*."

5. Conversion of One System to the Other. Any known fraction of two right ∠s is easily expressed in circular measure. For, since 2 right ∠s $= \pi$,

we have 1 right ∠ $= \frac{\pi}{2}$,

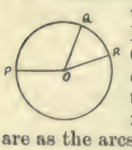
$$45^\circ = \frac{1}{2} \text{ a right } \angle = \frac{\pi}{4},$$
$$60^\circ = \frac{1}{3} \text{ of 2 right } \angle\text{s} = \frac{\pi}{3},$$
$$30^\circ = \frac{1}{6} \text{ of 2 right } \angle\text{s} = \frac{\pi}{6}.$$

In general, if D is the number of degrees in any angle, and θ the number of radians in the same angle, then each of the fractions, $\frac{D}{180}$ and $\frac{\theta}{\pi}$, denotes the ratio of the angle to two right angles.

$$\therefore \frac{D}{180} = \frac{\theta}{\pi}.$$
$$\therefore D = \frac{180}{\pi} \times \theta, \text{ and } \theta = \frac{\pi}{180} \times D.$$

Thus, to bring degrees to circular measure we multiply by $\frac{\pi}{180}$; while, to express circular measure in degrees we multiply by $\frac{180}{\pi}$. If an angle is given in degrees, minutes and seconds, it should be expressed as the decimal of a degree before being converted.

6. Circular Measure of any Angle at the Centre of a Circle.



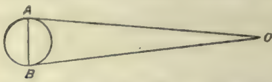
Let PQR be a circle whose centre is O. Let ROP be any angle at the centre. Make the arc RQ equal to the radius. Then ∠ROQ is a radian. Now, angles at the centre are as the arcs on which they stand.

$$\therefore \frac{\angle \text{ROP}}{\angle \text{ROQ}} = \frac{\text{arc RQP}}{\text{arc RQ}};$$
$$i.e., \frac{\angle \text{ROP}}{\text{a radian}} = \frac{\text{arc RQP}}{\text{radius}}.$$
$$\therefore \angle \text{ROP} = \frac{\text{arc RQP}}{\text{radius}} \times \text{a radian}.$$

Thus, *the circular measure of an angle at the centre of a circle is the ratio of the arc on which it stands, to the radius.*

EXAMPLE. The angle subtended by the diameter of the sun at the observer's eye is 32′. Find the sun's diameter, approximately, if the sun's distance is 90 million miles.

Let O be the observer's eye, AB the diameter of the sun. Now, since the ∠AOB is very small, and the sun's distance, OA, is very great, the diameter AB will be very small compared with OA. Hence, we may consider that AB is a very small portion of the circumference of a ⊙ whose centre is O and whose radius is 90 million miles.

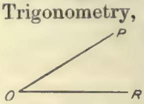


$$\therefore \text{Circular measure of } \angle \text{AOB} = \frac{\text{AB}}{\text{OA}};$$

i.e.,

$$\frac{\text{Sun's diameter}}{\text{90 million miles}} = \odot^{ar} \text{ measure of } 32'$$
$$= \odot^{ar} \text{ measure of } \frac{32}{60} \text{ degree}$$
$$= \frac{32 \times \pi}{60 \times 180}.$$
$$\therefore \text{Sun's diameter} = \frac{32 \times 22 \times 90{,}000{,}000}{60 \times 180 \times 7} \text{ miles}$$
$$= 838{,}095 \text{ miles}.$$

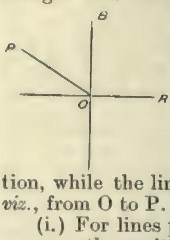
7. Use of the Signs + and −. In Trigonometry, angles of *any* magnitude are considered. Thus, starting from the position OR (called the *initial line*) the line OP revolves about the *origin* O, *in either direction*, and may make any number of revolutions before coming to its final position. We have, therefore, to make the following convention:



(i.) When an angle ROP is described by OP turning *in a direction contrary to the hands of a watch*, the angle ROP is *positive*. Thus, if the revolving line had turned through three right angles, the angle ROP would be represented by + 270°.

(ii.) When ROP is described by OP turning in the same direction as the hands of a watch, the angle ROP is *negative*. If OP had turned through a right angle, the ∠ROP would be − 90°.

Again, in measuring a given length along a straight line from a given point in it, it is necessary to know *in which direction* the line is to be measured. Hence, if lines measured in one direction are positive, lines in the opposite direction are called negative.



In the case of the revolving line OP, the positive direction, while the line turns, remains the same—*viz.*, from O to P. We have, then,

(i.) For lines parallel to the initial line OR, the positive direction is from O to R; the negative direction from R to O.

(ii.) For lines perpendicular to the initial line, the positive direction is from O to B, and the negative from B to O.

(iii.) The line OP is always positive.

Continued

FRENCH—SPANISH—ESPERANTO—GREEK

French by Louis A. Barbe, B.A.; Spanish by Amalia de Alberti and H. S. Duncan; Esperanto by Harald Clegg; Greek by G. K. Hibbert, M.A.

FRENCH

Continued from page 5949

By Louis A. Barbé, B.A.

VERBS

Use of the Subjunctive—continued

5. The verb must be in the subjunctive when it is preceded by a relative pronoun having for its antecedent a noun qualified by a superlative, or by some word equivalent to a superlative, such as: *le premier,* the first; *le dernier,* the last; *le seul,* the only: *Le chien est le seul animal dont la fidélité soit à l'épreuve,* The dog is the only animal whose fidelity can be relied on (lit. is proof).

When the superlative is followed by an indirect object the verb is in the indicative: *Le soleil est le plus grand des corps que l'on aperçoit dans le ciel,* The sun is the largest of the bodies that we perceive in the heavens.

6. After *quel que* (*quelle que, quels que, quelles que*), whatever; *qui que,* whosoever; *quoi que,* whatsoever, the subjunctive is required in the subordinate clause: *Quel que soit le mérite d'un homme, il ne peut échapper à l'envie,* Whatever a man's merit may be, he cannot escape envy.

7. *Quelque . . . que,* and *si . . . que,* meaning whatever, however, require the verb following them to be in the subjunctive: *Quelque effort que fassent les hommes, leur néant paraît partout,* Whatever effort men may make, their nothingness is everywhere apparent.

8. When *que* is used to avoid the repetition of *si,* the verb that follows it must be in the subjunctive: *Si vous passez par cette ville et que vous puissiez disposer d'une couple de jours, ne manquez pas de vous y arrêter,* If you pass through that town, and if you can spare a couple of days, do not fail to make a stay there.

9. The subjunctive is used (*a*) after conjunctions indicating time before which, or time up to which, as *avant que, en attendant que, jusqu'à ce que;* (*b*) after conjunctions indicating purpose or result, as *afin que, pour que, de crainte que, de peur que;* (*c*) after conjunctions implying a condition or supposition, as *en cas que, au cas que, à moins que . . . ne, pourvu que, supposé que;* (*d*) after conjunctions implying a concession, as *quoique, bien que, encore que, soit que . . . soit que; soit que . . . ou que; pour peu que, si tant est que;* and (*e*) after conjunctions involving a negation, as *non que, non pas que, loin que, sans que:*

(*a*) *Je lui ai payé cette somme avant qu'il partît,* I paid him that amount before he left.

(*b*) *Ce livre est toujours sur le bureau, afin qu'on puisse le consulter,* That book is always on the desk, so that it may be consulted.

(*c*) *Pourvu qu'on sache la passion dominante de quelqu'un, on est assuré de lui plaire,* Providing we know the master-passion of any one, we are sure to please him.

(*d*) *Quoiqu'il soit pauvre, il est un honnête homme,* Although he is poor, he is an honest man.

(*e*) *Je dis cela, non que je veuille me plaindre, mais pour que vous sachiez ce qui s'est passé,* I say this, not that I wish to complain, but that you may know what has taken place.

10. The subjunctive occurs in elliptical sentences expressing a wish or a command; and, in such cases, the conjunction *que* is sometimes omitted: *Que Dieu vous ait en sa sainte garde,* May God have you in His holy keeping; *Vive le Roi!* Long live the King!

11. The subjunctive is used idiomatically in the expression *je ne sache,* followed by a negation, and *que je sache,* preceded by one: *Je ne sache rien qui soit plus digne de notre amour que la vertu,* I know of nothing that is more worthy of our love than virtue; *Cette affaire ne le regarde nullement, que je sache,* This matter does not concern him in any way that I know of.

Sequence of Tenses. 1. When the verb of the governing clause is in the present, whether indicative, subjunctive, or imperative, or in either of the future tenses of the indicative, the verb of the subordinate clause must be in the present subjunctive if it be intended to express an action or a state considered as either present or future in respect of the governing verb: *Il faut que je sorte maintenant,* I must go out now.

2. When the verb of the governing clause is in the present, whether indicative, subjunctive, or imperative, or in the future indicative, the verb of the surbordinate clause must be in the perfect subjunctive if it be intended to express an action, or a state considered as past in respect of the governing verb: *Je ne crois pas que vous ayez fait tous vos efforts,* I do not think you have done your utmost.

3. When the verb of the governing clause is in any past tense of the indicative or subjunctive, or in either tense of the conditional, the verb of the subordinate clause must be in the imperfect subjunctive if it be intended to express an action or a state considered as either present or future in respect of the governing verb: *Je voulais qu'on retardât le départ,* I wished the departure to be delayed.

4. When the verb of the governing clause is in any past tense of the indicative or of the subjunctive, or in either tense of the conditional, the verb of the subordinate clause must be in the pluperfect subjunctive if it be intended to express an action or a state considered as past in respect of the governing verb: *Je ne savais pas que vous m'eussiez écrit,* I did not know that you had written to me.

5. When the verb of the governing clause is in the past indefinite, the verb of the subordinate clause is frequently put in the past subjunctive instead of the pluperfect subjunctive: *Il a fallu qu'il se soit donné bien des peines,* He must have given himself a great deal of trouble.

6. A past indefinite in the governing clause may be followed by a present subjunctive in the subordinate clause to express an action or a state which is still present: *Cet auteur n'a employé aucune fiction qui ne soit une image de la vérité,* That author has used no fiction that is not an image of truth.

Agreement of the Past Participle

1. The past participle, when not accompanying an auxiliary verb, is practically an adjective, and agrees in gender and number with the noun or pronoun to which it refers: *Voyez-vous là-bas ces collines couronnées de bois sombres?* Do you see yonder those hills crowned with dark woods?

Exception: A certain number of past participles really become prepositions when they precede a substantive, and are then invariable. The chief of them are: *attendu,* considering; *vu,* seeing; *excepté,* except; *y compris,* including; *ci-inclus,* enclosed: *Excepté vous et moi,* Except you and me.

These participles agree in the ordinary way when they come after the noun or pronoun to which they refer: *Vous et moi exceptés,* You and I excepted.

2. When the past participle is accompanied by the verb *être,* to be, as is the case in all the tenses of passive verbs and in the compound tenses of some neuter or intransitive verbs, it always agrees in gender and number with the subject of the verb: *La vertu obscure est souvent méprisée,* Obscure virtue is often despised.

3. When the past participle is used in connection with *avoir,* to have, to form the compound tenses of an active verb, it agrees in gender and number with the direct object of the verb, providing that direct object precedes the verb: *J'ai reçu toutes les lettres que vous m'avez adressées,* I have received all the letters which you have addressed to me.

In this example *reçu* does not agree with the direct object, because that object—*i.e., toutes les lettres*—comes after it. *Adressées,* on the other hand, agrees with its direct object *que,* because that direct object precedes it.

4. It follows from this rule that, as a neuter verb cannot have a direct object, its participle is always invariable: *La justice et la modération de nos ennemis nous ont plus nui que leur valeur,* The justice and moderation of our enemies have done us more harm than their valour. In this example, the neuter verb *nuire* (= to injure, to do harm) governs *nous* in the dative, or indirect object. There can, consequently, be no agreement.

5. Pronominal, or reflexive, verbs are conjugated in their compound tenses with the help of *être,* to be. This auxiliary, however, is equivalent to *avoir,* to have; and the rule for the agreement of the past participle is the same as in the case of the past participle conjugated with *avoir* [see above, 3]: *Ces hommes se sont repentis,* Those men have repented. In this sentence *se* is the direct object of the pronominal verb *se repentir,* to repent; and consequently the past participle agrees with it.

Elle s'est plu à me contredire, She delighted in contradicting me. In this example, the pronominal verb *se plaire,* to delight in, is made from the intransitive verb *plaire.* The pronoun s' (= *se*) is governed by it in the dative. Consequently there is no agreement.

Nous nous sommes lavé les mains, We have washed our hands. Here the direct object of the pronominal verb *se laver* is the noun *mains*; and, as it does not precede the verb there is no agreement. On the other hand, the past participle agrees with the second *nous* in the following example, where it is the direct object: *Nous nous sommes lavés,* We have washed (ourselves).

6. The past participle of an impersonal verb, or of a verb used impersonally, can never have a direct object with which to agree: *Les chaleurs qu'il a fait pendant l'été,* The heat which was experienced during the summer. Here *il a fait* (= it has made) is used impersonally and idiomatically to indicate existence (= there has been).

7. The past participle *été* never changes under any circumstances: *La maison a été brulée,* The house was burnt. *Nous sommes ce que nous avons toujours été,* We are what we always have been.

Special Cases. 1. When the past participle conjugated with the auxiliary *avoir* and preceded by a direct object is followed by an infinitive, that past participle agrees with the object if it is the governing verb. It does not agree if the infinitive is the governing verb: *Les dames que nous avons entendues chanter,* The ladies whom we heard sing (singing). Here, the past participle agrees because it belongs to the verb governing *que,* whom. It is to be noted that in this case, the French infinitive *chanter* may be translated by the English present participle *singing.*

Les airs que nous avons entendu chanter, The melodies which we heard sung. Here the past participle does not agree, because not it, but *chanter* is the verb governing *que.* It is to be noted that in this case the French infinitive is translated by the English past participle *sung.*

The past participle *fait* does not come under this rule. When immediately followed by an infinitive it always remains unchanged (*fait*): *Une femme s'est présentée à la porte; je l'ai fait passer,* A woman presented herself at the door; I made her pass in.

2. It frequently happens that a governing infinitive is understood after the past participles of *devoir, vouloir* and *pouvoir*—*i.e., dû, voulu, pu.* In that case the past participle does not agree with the preceding object: *Je lui ai rendu tous les services que j'ai pu,* I have rendered all the services which I could (*i.e.,* render him).

3. A past participle preceded by the relative pronoun *que,* and followed by the conjunction *que,* never agrees with the relative: *Les lettres que j'ai prévu que vous recevriez,* The letters which I foresaw you would receive.

4. The past participle does not agree with *en,* some, any: *Il a acheté plus de livres qu'il n'en a lu,* He has bought more books than he has read.

The past participle preceded by *en* may, however, agree with some other word also preceding it: *J'ai reconnu la maison d'après la description que vous m'en avez faite,* I recognised the house from the description you gave me of it.

5. After *le peu* the past participle remains unchanged if *le peu* is equivalent to "the want of": *Le peu d'affection que vous lui avez témoigné l'a découragé,* The little affection you showed him discouraged him.

If, on the contrary, *le peu* represents a positive quantity, a certain amount, the past participle agrees with the complement of *le peu*—*i.e.,* the noun coming after it: *Le peu d'affection que vous lui avez témoignée l'a encouragé,* The little affection you showed him encouraged him.

ADVERBS

Negation. 1. Negation is usually expressed by *ne* and *pas,* or *point* (which is rather stronger than *pas*). *Ce n'est pas moi qui vous l'ai dit,* It is not I who told you.

2. The second part of the negation is omitted after *savoir,* used with the meaning of *pouvoir,* to be able: *Je ne saurais en venir à bout,* I cannot manage it. In this construction the present conditional of *savoir* is used instead of the present indicative of *pouvoir.*

3. When *savoir* has its ordinary meaning of "to know" it requires *pas* when used negatively: *Il ne sait pas le français,* He does not know French.

4. When a verb used negatively is followed by a negative relative clause, that relative clause takes *ne* only: *Il n'y a personne qui ne le respecte*, There is no one but respects him.

5. When the negation is expressed by any word but "not," such as "never," "nobody," "nothing," etc., *ne* is used, but *pas* must be omitted: *Je ne dois rien*, I owe nothing.

6. In negations the order of the words is usually: first, *ne;* second, verb; third, second part of the negative expression. But when "nobody" or "nothing" is the subject of the sentence, *personne*, or *rien*, must precede *ne*: *Personne n'a voulu lui parler*, Nobody would speak to him.

7. "Neither—nor" must be expressed by *ne—ni*: *Elle n'a ni frère ni sœur*, She has neither brother nor sister.

8. Several negative expressions may occur in the same sentence, in which case *ne* is used only once: *Personne ne m'a jamais rien dit*, Nobody has ever said anything to me.

9. *Ne* is used alone and without any negative meaning: (*a*) After verbs and other expressions indicating fear: *Je crains que vous ne perdiez votre argent*, I fear you will lose your money. (*b*) After *que*, "than," in comparisons of superiority or inferiority having a verb for their second term: *Vous écrivez mieux que vous ne parlez*, You write better than you speak. (*c*) After *à moins que*, "unless": *J'irai me promener, à moins qu'il ne fasse mauvais temps*, I shall go for a walk unless it is bad weather.

Special Remarks. 1. *Auparavant* and *avant* both mean "before" (of time); but *auparavant* being an adverb has no complement, whilst *avant*, which is a preposition, requires one: *Nous lui avions déjà écrit quelques mois auparavant*, We had already written to him a few months before; *Je le verrai avant vous*, I shall see him before you.

2. *Davantage* and *plus* both mean "more," but *davantage* must not be followed by *que* nor by *de*. It therefore stands only at the end of a sentence: *Vous avez de l'argent, mais il en a davantage*, You have money, but he has more.

3. *Dessus*, "on, over"; *dessous*, "under, underneath"; *dedans*, "within, in"; *dehors*, "without, out," which are adverbs and take no complement, are to be carefully distinguished from the corresponding prepositions *sur*, *sous*, *dans*, *hors*, which require complements. These adverbs are frequently used instead of a preposition and a pronoun referring to an inanimate object: *Nous ouvrîmes la boîte, mais il n'y avait rien dedans*, We opened the box, but there was nothing in it.

4. *Plus tôt* and *plutôt* both mean "sooner," but *plus tôt* refers to priority of time, whilst *plutôt* indicates preference: *Il est revenu plus tôt que je ne croyais*, He has come back sooner than I thought; *Donnez-nous la mort plutôt que l'esclavage*, Give us death rather than slavery.

5. *Au moins* and *du moins* both mean "at least," but *au moins* indicates a minimum, whilst *du moins* corrects or limits a former statement: *Ce voyage vous coûtera au moins mille francs, du moins c'est ce qu'il m'a coûté l'année dernière*, That journey will cost you at least forty pounds—at least, that is what it cost me last year.

PREPOSITIONS

1. Prepositions, with the single exception of *en*, require verbs that follow them to be in the infinitive. After *en* the verb must be in the present participle: *En voyant son père il se mit à pleurer*, On seeing his father he began weeping.

2. The prepositions *à*, *de*, and *en* must be repeated before each complement: *Il dut la vie à la clémence et à la magnanimité du vainqueur*, He owed his life to the clemency and the magnanimity of the victor.

3. Other prepositions are usually repeated when the complements are opposed to each other in meaning: *Dans la ville et dans la campagne*, in town and country.

4. The prepositions *jusque*, as far as; *attenant*, adjoining; *par rapport*, with regard to; *quant*, as to, require the preposition *à* after them: *Il nous a accompagnés jusqu' à Londres*, He accompanied us as far as London.

But when *jusque* is construed with *où*, *ici*, *là*, *dans*, and *chez* it does not take *à* as well: *Il nous a accompagnés jusque chez nous*, He accompanied us as far as our house.

5. The preposition *de* is required after *auprès*, near; *autour*, around; *loin*, far; *près*, near; and *proche*, close, as well as after prepositional phrases, including a noun, as *à force*, by dint: *Ils demeurent près de l'église*, They live near the church.

6. *Avant* (before) requires no preposition before a noun or pronoun, but takes *de* before a verb: *Viendrez-vous nous voir avant de partir?* Will you come and see us before leaving?

7. When helping to form compound words, the preposition *à* conveys the idea of fitness, agency, peculiarity: *Un bateau à vapeur*, a steamboat.

8. The preposition *de* is joined to a noun of material to form a qualifying phrase: *Un chapeau de paille*, a straw hat.

9. The preposition *de* is used after *plus* and *moins* to express "than" before a numeral: *Vous avez plus de dix fautes*, You have more than ten mistakes.

10. The preposition *de* is used before *plus* and *moins* to express "more" and "less," when those words follow a numeral with a noun expressed or understood: *Vous-avez douze fautes; il en a deux de moins*, You have twelve mistakes; he has two less.

11. The preposition *de* is used for "by" in expressions indicating excess or difference: *Vous le dépassez de toute la tête*, You are taller than he (exceed him) by a whole head.

12. The preposition *de* is used for "with" after verbs and adjectives expressing plenty, want, providing, depriving, etc.: *Il s'était rempli les poches de petits cailloux*, He had filled his pocket with little pebbles.

13. When a cardinal number is preceded by *en*, the adjective or past participle that follows that numeral usually takes *de*: *Sur cent habitants, il y en a deux de riches*, Out of a hundred inhabitants there are two rich.

14. When the verb "to be" has an infinitive coming after it for its logical subject that infinitive takes *de* or *que de* before it: *C'est mal de* (or *que de*) *parler comme cela*, It is wrong to speak so.

15. An infinitive following "than" takes *de* before it: *Il mourrait plutôt que de trahir sa patrie.* He would die rather than betray his country.

16. When a noun or an adjective used substantively serves as an epithet to qualify another noun, *de*, meaning "of a," is put before the qualified noun: *Un drôle d'individu*, a queer fellow.

17. The essential difference between *en* and *dans* is that *en* is only exceptionally used with the definite article *le*, *la*, *les*, whilst *dans* always requires it. Consequently nouns following *en* have usually an indeterminate meaning: *On l'a mené en prison*, He has been taken to prison; *On lui a permis*

d'entrer dans la prison, He was allowed to enter the prison.

18. *En* frequently means "in the character of," "like": *Vous parlez en soldat; je dois agir en roi,* You speak as a soldier; I must act as a king.

19. In expressions of time there is a great difference between *en* and *dans. En* indicates "time, how long," whilst *dans* indicates "point of time when": *Je ferai cet ouvrage en deux jours,* I shall take two days to do that work; *Je ferai ce travail dans deux jours,* I shall begin doing that work two days from now.

20. *En* is used in connection with all the seasons except spring, which takes *au*: *Il fait moins chaud au printemps qu' en été,* It is less warm in spring than in summer.

21. *A travers* and *au travers* both mean "through," but *à travers* means "through" in the sense of "across"; whilst *au travers,* which is always followed by *de,* rather means "right through," and implies a greater effort: *Nous courûmes à travers les champs,* We ran through the fields; *Il se fraya un passage au travers de la haie,* He forced his way through the hedge.

22. *Vers* and *envers* both mean "towards"; but *vers* refers to direction, whilst *envers* is used figuratively, in connection with feeling, sentiment, etc.: *Le premier moment de la vie est le premier pas vers la mort,* The first moment of life is the first step towards death; *Il s'est montré ingrat envers ses bienfaiteurs,* He showed himself ungrateful towards his benefactors.

CONJUNCTIONS

1. The conjunction *ni,* "neither," may be either used or omitted before the first of several subjects: *Le soleil ni la mort ne se peuvent regarder fixement,* Neither the sun nor death can be steadfastly gazed at; *Ni l'or ni la grandeur ne nous rendent heureux,* Neither gold nor greatness makes us happy.

2. The conjunction *ni* may be used to avoid the repetition of *sans,* "without"; *Sans crainte ni pudeur,* or *sans crainte et sans pudeur,* without fear or shame.

3. The English expressions "nor . . . either" "not . . . either," are to be translated by *ni . . . non plus, ne . . . pas non plus*: *Je ne le connais pas, ni elle non plus,* I do not know him nor her either: *Je ne lui écris pas, et il ne m'écrit pas non plus,* I do not write to him, and he does not write to me either.

4. The expression "either . . . or" may be expressed either by using *ou* before each term, or omitting it before the first: *Le ciel n'est ouvert ou qu'aux innocents ou qu'aux pénitents,* Heaven is open either to the innocent only, or the penitent only; *Le bonheur ou la témérité ont pu faire des héros,* Either good fortune or rashness may have produced heroes.

5. *Soit* and *soit que* both mean "whether," but *soit* precedes a noun, whilst *soit que* is followed by a verb. Both of them may be repeated before each term, or replaced by *ou* or *ou que* before the second: *La fortune, soit bonne ou mauvaise, soit passagère ou constante, ne peut rien sur l'âme du sage,* Fortune, whether good or bad, whether fleeting or constant, has no power on the soul of the wise man.

6. The conjunction *que* may be used to prevent the repetition of either *comme,* as; *quand,* when; or *si,* if. When replacing the last of these, it requires the verb that follows it to be in the subjunctive: *Comme nous l'avons déjà dit et que nous le verrons plus clairement ailleurs,* As we have already said, and as we shall see more clearly elsewhere; *Quand on est jeune et qu'on se porte bien on devrait aimer les exercices du corps,* When we are young, and are in good health we ought to like bodily exercise; *Si vous le rencontrez et que vous lui parliez, faites-lui mes amitiés,* If you meet him and speak to him, give him my kind regards.

7. *Que* may be used instead of *afin que,* in order that; *sans que,* but that; *lorsque,* when; *depuis que,* since; *de peur que,* lest; and *avant que,* until: *Approchez que je vous parle,* Draw near, that I may speak to you; *Je n'irai pas me coucher que ma besogne ne soit finie,* I shall not go to bed until my task is ready.

8. When, however, *que* takes the place of a conjunction which does not itself require the subjunctive (except the conjunction *si*), it is not followed by the subjunctive: *Je le ferai quand je serai revenu et que j'aurai le temps,* I shall do it when I have returned and have the time.

Translation

BONNES RÉSOLUTIONS

Si je me lève tard et que je traîne tout le jour, je commencerai à peine mon ouvrage à la nuit; mais je me coucherai tôt, je me lèverai tôt, et j'obtiendrai par ce moyen, santé, richesse et sagesse. Je m'efforcerai d'être laborieux, afin que je n'aie jamais à craindre la disette (want). Il n'est pas nécessaire que je trouve un trésor, ni qu'il m'arrive un riche héritage; mon activité me suffira. Je travaillerai dès aujourd'hui, car je ne sais pas si je n'en serai pas empêché demain. Je rougirai de ne rien faire, alors que j'ai tant à faire pour moi-même, pour ma famille, pour mon pays. Je prendrai mes outils sans mitaines et je me souviendrai que chat ganté ne prend pas de souris. Peut-être me sentirai-je parfois le bras trop faible; mais je tiendrai ferme et je triompherai de tous les obstacles. J'emploierai bien mon temps, parce que je veux gagner du loisir et comme je ne suis pas sûr d'une minute, je ne perdrai pas une heure.

KEY TO TRANSLATION

GOOD RESOLUTIONS

If I get up late and dawdle (drag) all day, I shall hardly begin my work at night; but, I shall go to bed early, I shall get up early, and I shall obtain by that means health, wealth, and wisdom. I shall strive to be industrious, so that I may never have to fear want. It is not necessary that I should find a treasure, nor that a rich legacy should come to me; my activity will suffice me. I shall work from this very day, for I do not know whether I shall not be prevented from (doing) it to-morrow. I shall blush to do nothing when I have so much to do for myself, for my family, for my country. I shall take up my tools without mittens, and I shall remember that a gloved cat catches no mice. Perhaps I shall sometimes feel my arm too weak; but I shall hold fast, and I shall triumph over all obstacles. I shall make good use of my time, because I wish to win leisure, and as I am not sure of a minute I shall not lose an hour.

FRENCH *concluded*

 Continued from page 5804

COMMERCIAL CORRESPONDENCE

In Spanish commercial letters the name and address of the recipient is placed at the head of the letter. The usual beginning is "Muy Señor mio," equivalent to "Sir," or "Dear Sir"; or "Muy Señores mios," equivalent to "Dear Sirs" or "Gentlemen." If the letter is written in the plural, as from a firm, not from an individual, the beginning is "Muy Señor nuestro," or "Muy Señores nuestros."

The closing phrases of elaborate politeness have become, as in ordinary correspondence, a mere matter of form, and are nearly always abbreviated to the initial letters of each word. Examples:

"*Su seguro servidor que su mano besa,*" abbreviated to S.S. q. s. m. b., equivalent to "Your obedient servant."

"*Somos de V. atentos seguros servidores que su mano besa,*" abbreviated to at. S.S. q. s. m. b., equivalent to "We are yours faithfully."

The abbreviations need not necessarily be capitals. The q. s. m. b. (who kisses your hand) is sometimes placed after the signature. Many abbreviations are allowable, as may be seen in the following letters.

Commercial Vocabulary

[For other terms see Commercial Phraseology and Vocabulary, pages 5515–6.]

Account, *cuenta*
On account, *á cuenta*
Advice, *aviso*
Address, *señas*
Advertisement, *anuncio, aviso*
Agreement, *convenio, contrato*
Allowance, *abono, compensacion*
Assets, *activo, balance*
Audit, *balance de cuentas*
Auditor, *auditor, revisor*
Balance, *balance, saldo*
Bank post bills, *giros al portador*
Bank rate, *tasa del banco*
Bill of lading, *conocimiento de embarque*
Bill of exchange, *letra de cambio*
Bill broker, *corredor de cambios*
To draw a bill, *girar una letra*
Brokerage, *corretage*
Buyer, *comprador*
Bankrupt, *insolvente, quebrado*
Cash account, *cuenta de caja*
Chartered accountant, *perito mercantil*
Clearance, *despacho*
Customs tariff, *arancél aduanero*
Demand draft, *letra á la vista*
Demurrage, *estadias*
Discount, *descuento*
Dock dues, *derechos de dique*
Dry goods, *generos de paño*
Deposit (payment on account), *señal*
Endorsement, *endoso*
Estimate, *presupuesto*
Excise, *sisa*
Failure, *quiebra*
Firm, *razon social, casa*
Goodwill, *traspaso (de tienda ó parroquianos)*
Gross weight, *peso bruto*
Guarantor, *garante, fiador*
Instalment, *plazo*
Joint-stock company, *sociedad por acciones*
Leakage, *merma*
Liabilities, *pasivo*
Lighterage, *gabarraje*
Limited liability company, *sociedad annónima*
Mail, *correo, mala*
Market price, *precio del mercado*
Money order, *giro mútuo*
Paper currency, *papel moneda*
Power of attorney, *poder*
Quotation, *cotizacion*
Receipt, *recibo*
Retail, *venta al pormenor*
Security, *seguridad, garantia*
Shareholders, *accionistas*
Sinking funds, *fondos de amortizacion*
Standard, *tipo*
Stock-jobber, *agiotador*
Stock-taking, *inventario*
Voucher, *comprobante*
Tender, *oférta*
Trustee, *administrador*
Underwriter, undersigned, *asegurador, infrascrito*
Wholesale, *venta al por mayor*

The following abbreviations are constantly used:

á/c, á cuenta, on account
á/f, á favor, favour of
á/v, á la vista, at sight
c/c, cuenta corriente, account current
d/f, dias fecha, day's date
d/v, dias vista, day's sight
fha., fecha, date
m/c, mi cuenta, my account
ppdo., proximo pasado, last month
Rs., reales, reals (Spanish coin)
s/c, su cuenta, your account
S. E. U. O., salvo error u omision, errors or omissions excepted

Commercial Letters

Circular. London, 1 December, 1905.	Circular. Londres, 1 Diciembre, 1905.
Messrs. A.B.C. Gentlemen,	Sres. A.B.C. Muy sres mios,
I have the pleasure of informing you that I have this day started business as a commission and consignment agent under the style and title of "John Brown."	Tengo el gusto de participar a Vds que con esta fecha y bajo la razon social de "John Brown," he establecido en esta ciudad una casa de comisiones y consignaciones.
An adequate capital, and wide experience in buying and selling articles in demand here, and those exported hence, enable me to offer you such goods upon the most advantageous terms obtainable, and encourage me to hope for the favour of your esteemed orders.	Un capital adecuado y una larga experiencia en la compra y venta de articulos que se consumen en esa y de todos los que de ahi se exportan, me colocan en posicion de ofrecer a Vd todas las ventajas obtenibles en estos mercados y me hace esperanzar que se dignaran Vds favorecerme con sus ordenes.
Kindly note my signature at the foot hereof.	Suplico á Vds se sirvan tomar nota de mi firma al pié de la presente.
I beg to remain, Your obedient servant, JOHN BROWN.	Tengo el gusto de suscribirme de Vds atto. S.S. q.s.m.b. JOHN BROWN.

Seville,
10 December, 1905.

Señor Don John Brown,
London.

Dear Sir,

We are in receipt of the circular dated the 1st inst. which you kindly sent us.

Although at present our business with England is not very extensive, we shall be pleased to enter into relations with the firm you have just established, and as a beginning request you to buy on our account and send by the first steamer bound for this place :

20 bags of Ceylon cinnamon,
20 bags of pepper, and
10 bags of Zanzibar cloves,

all upon the most advantageous terms as to price and quality.

For the amount of the invoice we authorise you to draw on us at three months' date, with the assurance that we shall honour same on presentation.

We remain,
Your obedient servants,
A.B.C.

London,
28 December, 1905.

Messrs. A.B.C.,
Seville.

Gentlemen,

I have duly received your esteemed favour of the 10th inst. containing your order for—

20 bags of Ceylon cinanmon
20 bags of pepper, and
10 bags of Zanzibar cloves,

and I beg to thank you for this first order and to inform you that I have effected the purchase and shipped the said goods per steamer "Velasquez," which left yesterday for Seville.

I enclose the bill of lading, certificate of origin, and the invoice, which amounts to £.

In accordance with your instructions I have to-day drawn for said amount on your good

Sevilla,
10 Diciembre, 1905.

Señor Don John Brown,
Londres.

Muy Sor nuestro :

Hemos recibido la circular que con fecha 1° del actual se ha servido Vd dirigirnos.

Aunque nuestros negocios con Inglaterra no son hoy de grande importancia, nos sera grato entrar en relaciones con la casa que acaba Vd de establecer y como primera operacion, le supplicamos compre por nuestra cuenta y nos remita en el primer vapor que salga con este destino:

20 churlas canela Ceilan,
20 sacos pimienta, y
10 sacos clavillos de Zanzibar,

cuya compra se servira efectuar en los mejores condíciones en cuanto á precios y calidad.

Por el importe de la factura, le autorizamos à girar a nuestro cargo y á 3 meses fecha, en la seguridad de nuestra buena acogida á su presentacion.

Quedamos de Vd attos.
S.S. q.s.m.b.
A.B.C.

Londres,
28 Diciembre, 1905.

Sres A.B.C.,
Sevilla.

Muy Sres mios :

En su dia fui favorecido por su apb[le] del 10 del actual en la que se sírviéron Vds pedirme

20 churlas canela Ceilan
20 sacos pimienta, y
10 sacos clavillos de Zanzibar,

doy a Vds las mas expresivas gracias por este primer pedido y me es grato participarles que habiendo efectuado la compra he logrado embarcar dichos efectos en el vapor "Velazquez" que salió ayer para Sevilla.

Incluyo el conocimiento de embarque, certificado de origen, y factura correspondiente que asciende a £.

De acuerdo con su autorizacion he girado con esta fecha à cargo de Vds y orden propia por

selves to my own order, which draft kindly honour on presentation.

I sincerely hope that you will find the result of this first transaction satisfactory, and that you will continue to favour me with further orders.

I remain
Your obedient servant,
John Brown.

Malaga, 190 .

Mr. John Brown,
London.

Dear Sir,

Our mutual friends, Messrs. A.B.C., of Seville, have kindly given me the name of your esteemed firm. I have been for some time interested in developing certain mines of limonite iron ore of excellent quality which I possess in this province, and as I shall shortly be able to dispose of 4,000 tons a month, I wish to arrange with some well-known firm in England to contract with the leading founders of that country for the aforesaid quantity of mineral.

In order that the quality of my mineral may be appreciated there, I have sent 2 cwt. per "Pelayo," which has just left for London, which I consider a sufficient quantity to enable you to form an opinion of its good quality.

There is no objection to your having the samples I am sending analysed at my expense, as I am sure that the result will be the same as that obtained here.

The commission I am disposed to offer you is 3d. (threepence) per ton, upon the express condition that all benefits accruing from the charter parties shall be for my account.

Hoping to hear from you on this matter shortly,

I beg to remain,
Yours, &c.

la citada suma cuyo giro suplico a Vds se sirvan honrar á su presentacion.

Mucho celebraré qus queden Vds satisfechoe del resultado de esta primera operacion y que continuen favore ciendome con sus nuevos pedidos.

Me repito do Vd at.
S.S. q.s.m.b.
John Brown.

Malaga, 190 .

Sor Don John Brown,
Londres.

Muy sor mio,

Nuestros mútuos amigos los Sres A.B.C. de Sevilla, han tenido la amabilidad de facilitarme el nombre de su respetable casa. Desde hace algun tiempo me ocupo de trabajar y desarrollar unas minas de hierro limonete de excelente calidad que poseo en esta provincia, y como dentro de poco tiempo podré disponer de unas 4,000 toneladas mensuales, desearia entenderme con una casa de conocida reputacion en esa para hacer contratos con los fundidores mas importantes de ese pais por la referida cantidad de mineral.

Para que en esa puedan apreciar la calidad de mi mineral, por el vapor "Pelayo" que acaba de zarpar para Londres, le remito 2 quintales cuya cantidad considero sea suficiente para que pueda Vd formar juicio de lo bueno del mineral.

No hay inconveniente en que por mi cuenta haga Vd analizar las muestras que hoy le mando en la seguridad que el resultado habrá de ser ígual al obtenido en esta.

La comision que estoy dispuesto á conceder á Vd, es de 3d (tres peníques) por tonelada con la condicion expresa que todas las ventajas que se obtengan en los contratos de fletamentos serán para mi.

Aguardando recibir pronto sus noticias sobre este particular, me es grato ofrecerme de Vd at S.S. q.s.m.b.

Continued

Continued from page 5950

Verbs (Imperative Mood)

The Imperative Mood of the verb is formed by adding *u* to the root word.

Examples: *Restu tie, kaj aŭskultu min,* Stay there and listen to me; *Mi mortu se tio estus vera,* May I die if that be true; *Venu unu, venu ĉiuj, mi timas neniun,* Come one, come all, I fear nobody.

In addressing the second person (*vi, ci*), the pronoun, as in English, is generally omitted, but it may be inserted if preferred: *Vi foriru,* Go (you) away.

It may often be found necessary to use this mood in a subordinate sentence subjoined to the main sentence by the conjunction *ke*, but care must be taken to show clear distinction in making choice between this mood, which has only reference to *purpose* or *end to be attained,* and one of the tenses.

The verbs which may lead to the use of the imperative in a subordinate sentence are: *Deziri, peti, voli, ordoni* (to order), *meriti* (to merit), *esti necese, konsenti, permesi, bezoni, malpermesi,* and any others which, in a similar degree, possess a certain imperative sense or intention.

Por ke is always followed by the imperative mood because the expression leads up to the idea of something being necessary or wanted.

It will be convenient if a few examples are given to show how selection between this mood and a tense is arrived at in subordinate sentences:

Vi meritas, ke oni vergu vin. Translated, this means, "You deserve *to be* whipped," or, "You deserve that one *do* whip you." Here, in the word *vergu*, there is no consideration whatever as to time; there is simply an exhibition of the purpose contained in the verb *meritas.* But let us suppose that when the words are being spoken the whipping has taken place, is taking place, or will take place, then the imperative (or *ordona*) mood has no reference to the circumstances, and must be replaced by the tenses as follows:

Vi meritas, ke oni vergis vin, (literally) You deserve that you have been whipped; *Vi meritas, ke oni vergas vin,* (literally) You deserve that you are being whipped; *Vi meritas, ke oni vergos vin,* (literally) You deserve that you are going to be whipped.

Suffixes

EG denotes enlargement or intensity of degree.

Examples: *Granda,* great; *grandega,* immense; *krii,* to cry; *kriegi,* to yell.

AR denotes a collection of objects.

Examples: *Homo,* man; *la homaro,* humanity; *bovo,* ox; *bovaro,* herd of oxen.

AN denotes a partisan, member or inhabitant.

Example: *Vilaĝo,* village; *vilaĝano,* villager; *kortego,* court; *kortegano,* courtier.

ER denotes one object of a collection:

Examples: *Mono,* money; *monero,* coin; *akvo,* water; *akvero,* drop of water.

Vocabulary

avar', covetous, avaricious
bord', shore, bank
branĉ', branch
ĉerk', coffin
dolor', pain, ache
domaĝ', pity (s.)
dung', hire (servant, etc.)
efektiv', real, actual
etaĝ', stage, story
evit', avoid
falĉ', mow, cut
fel', hide, fleece
fer', iron
fond', start, found
fork', fork
glut', swallow
gut', drop, drip
haŭt', skin
ĥemi', chemical
ĥor', chorus
insekt', insect
kapr', goat
karb', coal
kolekt', collect
konfid', confide, trust
konfuz', confuse
konserv', preserve
korp', body
kret', chalk
krim', crime
kron', crown
log', entice
marŝ', march, go
muŝ', fly (insect)
odor', odour, smell
pak', pack
pentr', paint
pet', beg, ask for
pingl', pin
plafon', ceiling
plank', floor
pont', bridge
port', carry, wear
preĝ', pray
pres', print
radik', root
ramp', crawl
rekt', straight
ricev', receive

Exercise XV.

Allow me to pass, I beg! What a pity that you did not capture the criminal! Let all good citizens meet me here to-morrow in order that we may together carry our request to the king. Large drops of water began to fall from the ceiling. Go straight until you reach the forest, and be careful to avoid all roads which conduct left and right. The thought of that miserable miser causes me much pain. Receive, sir, my most hearty thanks. Look at that swarm of insects. Let there be peace in the world and everlasting goodwill in men's hearts. So be it! Twelve years ago I founded this group, and now the membership numbers three hundred and fifteen. Good, my friend, I congratulate you! May you always succeed as formerly! How sweet those flowers smell! A spark may cause a great fire. Although I do not actually know anything bad about that person, I nevertheless distrust him, but prefer to preserve my own opinion about him for the present. Here is a club member who collects coins. It is necessary for you to learn by heart the whole collection of roots in these vocabularies. The fly crawled over the goat's body. Collect the pins and pack them in the little box.

Key to Exercise XIII.

The rich man eats and lives well, but the poor man merely exists. Step by step men always go forward, in spite of everything which stands against them. The cripple wanted to swim across the lake, but in the middle he perished, and went to the bottom. At my desire, my uncle-in-law lent me the chest, and all the articles which it contained, except the silver spoons and the razors. The swallow rapidly flew past the river. Do you recollect the date when, happily, peace at last occurred? We ought to bless and imitate the good man. He nailed the lid on the box before he put the cups in. The shortsighted one grumbled with me because I wrote very small figures. One should honour and obey one's father and mother. I do not, for certain, remember the date of the letter, but I believe that the complainant wrote it about the fifth of the present month. He leaned himself on my arm and began to groan. I do not yet know exactly how much I possess in my pocket. Men everlastingly fight one against the other, and only the strong survive. What is the difference between this article and that? There is none. He had already quitted the town before I lived there. While I was feeding the pigs the poor man passed by and attentively watched them. Instead of speaking, she stood there with pale lips as though dumb. Whether I will allow that, depends on his precise desire, but in the meanwhile you must work diligently and have patience.

KEY TO EXERCISE XIV.

1. Li iris en sian kontoron, kaj skribis sian nomon sur la kambion. Ŝi ripetis sian rakonton al la kompata princino, kiu promesis zorgi pri ŝia infano. Kia estas lia metio? Sur tiu granda kverko estas nesteto, kies enhavon vi certe ŝatus ŝteli. Laŭ mia opinio, vi devus tuj respondi al la plej gravaj punktoj de lia letero. Kiom ŝuldas al vi lia filo? La regimento marŝis sur la marĉon, kaj preskaŭ ĉiuj soldatoj pereis. Ĉu la nova membrino ŝatas kremon aŭ lakton en sia teo? Tre malzorge li renversis la korbon, kiu estis plena je piroj. Kiu estas tie?

2. What beautiful lace! As you behaved so shamefully to-day you will not have the reward which I promised to you. The bee flies humming over the fields. The habits of these people are very shameful. What is your opinion as to my attempt? At early morn the dew lies on the petals of the roses. He pressed my hand, sadly said "Good-bye!" and disappeared from my sight for ever. Behind the curtains the prince, with all his diamonds, hid himself. In those circumstances I much regret that I shall not be able to buy your steel. They then commenced to speak very loudly and angrily; later, they menaced me and gave me a push, and finally they attempted to throw me out of the room. The hare runs very fast, especially when a wolf is behind. How majestic is that great fir!

Continued

GREEK

Continued from page 5952

By G. K. Hibbert, M.A.

SECTION I. VERBS

There are three *Voices* in Greek—Active, Middle, and Passive. The middle voice is primarily reflexive and represents the subject as acting upon himself or for his own benefit, or in some manner which concerns himself. Sometimes, however, there is no difference of meaning between the middle and the active. The passive is conjugated like the middle, except in two tenses, future and aorist.

The *Moods* are five—Indicative, Subjunctive, Optative, Imperative, and Infinitive (with Participles). These are used much as in English or in Latin, with the exception of the optative, the use of which will be explained later.

The *Tenses* are seven—Present, Imperfect, Perfect, Pluperfect, Aorist, Future, and Future Perfect. Of these the imperfect and pluperfect are found only in the indicative, and the future and future perfect are wanting in the subjunctive and imperative.

Many verbs have a *second* or *strong aorist* (all voices), and a second or strong perfect (active), while some have a second future in the passive. Very few verbs have both forms in any tense, and when this does occur the two forms generally differ in meaning.

The *Numbers* are three—Singular, Dual, and Plural; and the *Persons* are three, except in the imperative, where there are only second and third persons. The first person dual is the same as the first person plural, and being very rarely used is usually omitted in the schemes or paradigms of verbs.

The *principal parts* of a Greek verb are the first person singular, present, future, aorist, and perfect indicative active; the perfect and aorist indicative passive; and the second aorist (when it occurs). From these parts we can form all the other tenses of the verb—*e.g.*, the principal parts of λύω are λύω, λύσω, ἔλυσα, λέλυκα (active); λέλυμαι and ἐλύθην (passive).

There are two principal forms of *conjugation* of Greek verbs, that of verbs ending in ω and that of verbs ending in μι. Of these the former constitute by far the larger class. Examples of verbs in μι are δίδωμι, I give; τίθημι, I put; ἵστημι, I set

Model of Regular Greek Verb in ω

λύω, I loose

ACTIVE VOICE

[For Indicative Mood see pages 5520, 5657 and 5808]

Subjunctive Mood

	Present	*Aorist*	*Perfect* (rare)
1.	λύω	λύσω	λελύκω
2	λύῃς	λύσῃς	λελύκῃς
3.	λύῃ	λύσῃ	λελύκῃ
2.	λύητον	λύσητον	λελύκητον
3.	λύητον	λύσητον	λελύκητον
1.	λύωμεν	λύσωμεν	λελύκωμεν
2	λύητε	λύσητε	λελύκητε
3.	λύωσι	λύσωσι	λελύκωσι

Optative Mood

	Present	*Aorist*	*Perfect* (rare)
1.	λύοιμι	λύσαιμι	λελύκοιμι
2.	λύοις	λύσαις, λύσειας	λελύκοις
3.	λύοι	λύσαι, λύσειε	λελύκοι
2.	λύοιτον	λύσαιτον	λελύκοιτον
3	λυοίτην	λυσαίτην	λελυκοίτην
1.	λύοιμεν	λύσαιμεν	λελύκοιμεν
2.	λύοιτε	λύσαιτε	λελύκοιτε
3.	λύοιεν	λύσαιεν, λύσειαν	λελύκοιεν

The Future Optative λύσοιμι is conjugated similarly to λύοιμι.

Imperative Mood

	Present	*Aorist*	*Perfect* (rare)
2.	λῦε	λῦσον	λέλυκε
3.	λυέτω	λυσάτω	λελυκέτω
2.	λύετον	λύσατον	λελύκετον
3.	λυέτων	λυσάτων	λελυκέτων
2.	λύετε	λύσατε	λελύκετε
3.	λυέτωσαν	λυσάτωσαν	λελυκέτωσαν
	or λυόντων	or λυσάντων	

Infinitive Mood

Present	*Future*	*Aorist*	*Perfect*
λύειν	λύσειν	λῦσαι	λελυκέναι

Participles

	Present			*Future*	
λύων	λύουσα	λῦον	λύσων	λύσουσα	λῦσον
	Aorist			*Perfect*	
λύσας	λύσασα	λῦσαν	λελυκώς	λελυκυῖα	λελυκός

NOTE. The participles are thus declined:

Singular

Nom., Voc.	λύων	λύουσα	λῦον
Acc.	λύοντα	λύουσαν	λῦον
Gen.	λύοντος	λυούσης	λύοντος
Dat.	λύοντι	λυούσῃ	λύοντι

Dual

N., V., A.	λύοντε	λυούσα	λύοντε
Gen., Dat.	λυόντοιν	λυούσαιν	λυόντοιν

Plural

Nom., Voc.	λύοντες	λύουσαι	λύοντα
Acc.	λύοντας	λυούσας	λύοντα
Gen.	λυόντων	λυουσῶν	λυόντων
Dat.	λύουσι	λυούσαις	λύουσι

All participles in *ων*—as *λύσων*—are declined like *λύων*.

Participles in *ας*—as *λύσας*—are declined like *πᾶς* [see page 5656].

Perfect participles in *ως* are thus declined:

Singular

Nom., Voc.	λελυκώς	λελυκυῖα	λελυκός
Acc.	λελυκότα	λελυκυῖαν	λελυκός
Gen.	λελυκότος	λελυκυίας	λελυκότος
Dat.	λελυκότι	λελυκυίᾳ	λελυκότι

Dual

N., V., A.	λελυκότε	λελυκυία	λελυκότε
Gen., Dat.	λελυκότοιν	λελυκυίαιν	λελυκότοιν

Plural

Nom., Voc.	λελυκότες	λελυκυῖαι	λελυκότα
Acc.	λελυκότας	λελυκυίας	λελυκότα
Gen.	λελυκότων	λελυκυιῶν	λελυκότων
Dat.	λελυκόσι	λελυκυίαις	λελυκόσι

MIDDLE VOICE

Indicative Mood

Present	Imperfect	Future	Aorist	Perfect	Pluperfect
λύομαι	ἐλυόμην	λύσομαι	ἐλυσάμην	λέλυμαι	ἐλελύμην
λύει	ἐλύου	λύσει	ἐλύσω	λέλυσαι	ἐλέλυσο
λύεται	ἐλύετο	λύσεται	ἐλύσατο	λέλυται	ἐλέλυτο
λύεσθον	ἐλύεσθον	λύσεσ-θον	ἐλύσασ-θον	λέλυσ-θον	ἐλέλυσ-θον
λύεσθον	ἐλυέσθην	λύσεσ-θον	ἐλυσάσ-θην	λέλυσ-θον	ἐλελύσ-θην
λυόμεθα	ἐλυόμε-θα	λυσόμε-θα	ἐλυσάμε-θα	λελύμε-θα	ἐλελύμε-θα
λύεσθε	ἐλύεσθε	λύσεσθε	ἐλύσασθε	λέλυσθε	ἐλέλυσθε
λύονται	ἐλύοντο	λύσονται	ἐλύσαντο	λέλυνται	ἐλέλυντο

Subjunctive Mood

Present	Aorist	Perfect	
λύωμαι	λύσωμαι	λελυμένος	ὦ
λύῃ	λύσῃ	—	ᾖς
λύηται	λύσηται	—	ᾖ
λύησθον	λύσησθον	λελυμένω	ἦτον
λύησθον	λύσησθον	—	ἦτον
λυώμεθα	λυσώμεθα	λελυμένοι	ὦμεν
λύησθε	λύσησθε	—	ἦτε
λύωνται	λύσωνται	—	ὦσι

The perfect is made up of the perfect participle middle of *λύω* and the present subjunctive of *εἰμί*.

Optative Mood

Present	Aorist	Perfect	
λυοίμην	λυσαίμην	λελυμένος	εἴην
λύοιο	λύσαιο	—	εἴης
λύοιτο	λύσαιτο	—	εἴη
λύοισθον	λύσαισθον	λελυμένω	εἴητον
λυοίσθην	λυσαίσθην	—	εἰήτην
λυοίμεθα	λυσαίμεθα	λελυμένοι	εἴημεν
λύοισθε	λύσαισθε	—	εἴητε
λύοιντο	λύσαιντο	—	εἴησαν

The perfect optative is made up of the perfect participle middle of *λύω* and the optative of *εἰμί*. The dual and plural forms of the latter are usually shortened into *εἶτον, εἴτην, εἶμεν, εἶτε, εἶεν*.

Imperative Mood

Present	Aorist	Perfect
λύου	λῦσαι	λέλυσο
λυέσθω	λυσάσθω	λελύσθω
λύεσθον	λύσασθον	λέλυσθον
λυέσθων	λυσάσθων	λελύσθων
λύεσθε	λύσασθε	λέλυσθε
λυέσθωσαν or λυέσθων	λυσάσθωσαν or λυσάσθων	λελύσθωσαν or λελύσθων

Infinitive Mood

Present	Future	Aorist	Perfect
λύεσθαι	λύσεσθαι	λύσασθαι	λελύσθαι

Participles

Present	Future
λυόμενος, -η, -ον	λυσόμενος, -η, -ον
Aorist	**Perfect**
λυσάμενος, -η, -ον	λελυμένος, -η, -ον

The participles Middle are declined regularly.

PASSIVE VOICE

Present, Imperfect, Perfect and Pluperfect same as Middle.

Indicative Mood

Future	Aorist	Future Perfect
λυθήσομαι	ἐλύθην	λελύσομαι
λυθήσει	ἐλύθης	λελύσει
λυθήσεται	ἐλύθη	λελύσεται
λυθήσεσθον	ἐλύθητον	λελύσεσθον
λυθήσεσθον	ἐλυθήτην	λελύσεσθον
λυθησόμεθα	ἐλύθημεν	λελυσόμεθα
λυθήσεσθε	ἐλύθητε	λελύσεσθε
λυθήσονται	ἐλύθησαν	λελύσονται

Subjunctive Mood

Aorist
λυθῶ
λυθῇς
λυθῇ
λυθῆτον
λυθῆτον
λυθῶμεν
λυθῆτε
λυθῶσι

Imperative Mood

	Aorist
2.	λύθητι
3.	λυθήτω
2.	λύθητον
3.	λυθήτων
2.	λύθητε
3.	λυθήτωσαν or λυθέντων

Optative Mood

Future	Aorist	Future Perfect
λυθησοίμην	λυθείην	λελυσοίμην
λυθήσοιο	λυθείης	λελύσοιο
λυθήσοιτο	λυθείη	λελύσοιτο
λυθήσοισθον	λυθεῖτον	λελύσοισθον
λυθησοίσθην	λυθείτην	λελυσοίσθην
λυθησοίμεθα	λυθεῖμεν	λελυσοίμεθα
λυθήσοισθε	λυθεῖτε	λελύσοισθε
λυθήσοιντο	λυθεῖεν	λελύσοιντο

Infinitive

Future	Aorist	Future Perfect
λυθήσεσθαι	λυθῆναι	λελύσεσθαι

	Indicative	Subjunctive	Optative	Imperative	Infinitive	Participle
			ACTIVE VOICE			
Present / *Imperfect*	λύω / ἔλυον	λύω	λύοιμι	λῦε	λύειν	λύων
Future	λύσω	—	λύσοιμι	—	λύσειν	λύσων
Aorist	ἔλυσα	λύσω	λύσαιμι	λῦσον	λῦσαι	λύσας
Perfect / *Pluperfect*	λέλυκα / ἐλελύκειν	λελύκω	λελύκοιμι	[λέλυκε]	λελυκέναι	λελυκώς
			MIDDLE VOICE			
Present / *Imperfect*	λύομαι / ἐλυόμην	λύωμαι	λυοίμην	λύου	λύεσθαι	λυόμενος
Future	λύσομαι	—	λυσοίμην	—	λύσεσθαι	λυσόμενος
Aorist	ἐλυσάμην	λύσωμαι	λυσαίμην	λῦσαι	λύσασθαι	λυσάμενος
Perfect / *Pluperfect*	λέλυμαι / ἐλελύμην	λελυμένος ὦ	λελυμένος εἴην	λέλυσο	λελύσθαι	λελυμένος
			PASSIVE VOICE			
Present / *Imperfect* / *Perfect* / *Pluperfect*	Same as Middle					
Future	λυθήσομαι	—	λυθησοίμην		λυθήσεσθαι	λυθησόμενος
Aorist	ἐλύθην	λυθῶ	λυθείην	λύθητι	λυθῆναι	λυθείς
Future Perfect	λελύσομαι	—	λελυσοίμην	—	λελύσεσθαι	λελυσόμενος

Participles

Future	*Aorist*	*Future Perfect*
λυθησόμενος, -η, -ον	λυθείς, λυθεῖσα, λυθέν	λελυσόμενος, -η, -ον

NOTE. The aorist participle passive is declined as follows:

		Singular	
Nom.	λυθείς	λυθεῖσα	λυθέν
Acc.	λυθέντα	λυθεῖσαν	λυθέν
Gen.	λυθέντος	λυθείσης	λυθέντος
Dat.	λυθέντι	λυθείσῃ	λυθέντι
		Dual	
N., V., A.	λυθέντε	λυθείσα	λυθέντε
Gen., Dat.	λυθέντοιν	λυθείσαιν	λυθέντοιν
		Plural	
Nom.	λυθέντες	λυθεῖσαι	λυθέντα
Acc.	λυθέντας	λυθείσας	λυθέντα
Gen.	λυθέντων	λυθεισῶν	λυθέντων
Dat.	λυθεῖσι	λυθείσαις	λυθεῖσι

Paradigms

The best way of mastering the tenses and moods of a Greek verb is to write them out in a scheme, or model, or paradigm (as above), putting down only the first person singular of the tenses of the finite moods. These should then be learnt *across*, and thoroughly mastered. When once they are firmly fixed in the memory, it will be easy to recognise any part of a verb at once; and conversely, if one requires, say, the aorist imperative passive of λύω, running along the paradigm for that tense (ἐλύθην, λυθῶ, λυθείην, λύθητι), one reaches the desired haven without much trouble.

SECTION III. TRANSLATION

VOCABULARY

τότε, then, at that time
τε . . . καί, both . . . and (τε always follows its word, *cf.* μεγάλοι τε καὶ θολεροὶ below)
θολερός, turbid
ὀξύς, εῖα, ύ, swift
ῥεῦμα, -ατος, current
ἡ ὥρα, season
τὸ ἔτος, -ους, year
τὸ ὕδωρ, -ατος, water
ἀθροός, collected, in heaps
ἡ γῆ, land
ἔνθενπερ, whence
αὔξω, I increase
καθαρός, clear
ἰδεῖν, to see
περάσιμος, passable, able to be crossed
πλήν, except (governs genitive)

INDIAN RIVERS

καὶ τότε οἱ ποταμοὶ πάντες οἱ Ἰνδοὶ μεγάλοι τε καὶ θολεροὶ ἔρρεον (imperfect of ῥέω) καὶ ὀξεῖ τῷ ῥεύματι· ἦν γὰρ (= *for*, another connecting particle like δέ, and never put first in a sentence) ὥρα ἔτους. ταύτῃ δὲ τῇ ὥρᾳ (= and at this season) ὕδατά τε ἐξ οὐρανοῦ ἀθρόα καταφέρεαται (verb, = are carried down) ἐς (= εἰς) τὴν γῆν τὴν Ἰνδ...ήν, καὶ αἱ χιόνες αἱ τοῦ Καυκάσου, ἔνθενπερ τῶν πολ.ῶν ποταμῶν αἱ πηγαί εἰσι, αὔξουσιν αὐτοῖς (= their) τὸ ὕδωρ· χειμῶνος (= in winter) δὲ ὀλίγοι τε γίγνονται (= they become) καὶ καθαροὶ ἰδεῖν καὶ περάσιμοι πάντες, πλήν γε δὴ (two more connective particles, γε generally meaning *at least*, and δή being almost untranslatable in English) τοῦ Ἰνδοῦ καὶ Γάγγου.

KEY TO TRANSLATION [page 5952]

1. Death is terrible to the wicked. 2. The just were friendly to the poor. 3. The Greeks have not wise leaders. 4. In (the) beginning was the Word, and the Word was with God, and the Word was God. 5. Xenophon was the general of the Greeks. 6. Blessed are the poor in spirit: because theirs is the kingdom of heaven (literally: of the heavens). 7. The shepherds wonder at the snow in winter. 8. We shall save (our) native land from war. 9. There are few rivers in Greece. 10. O Persian, you have the bones of the messenger in the basket.

Continued

NOTE. The next instalment of the ITALIAN course appears in Part **43** of the SELF-EDUCATOR

END OF VOLUME VII.